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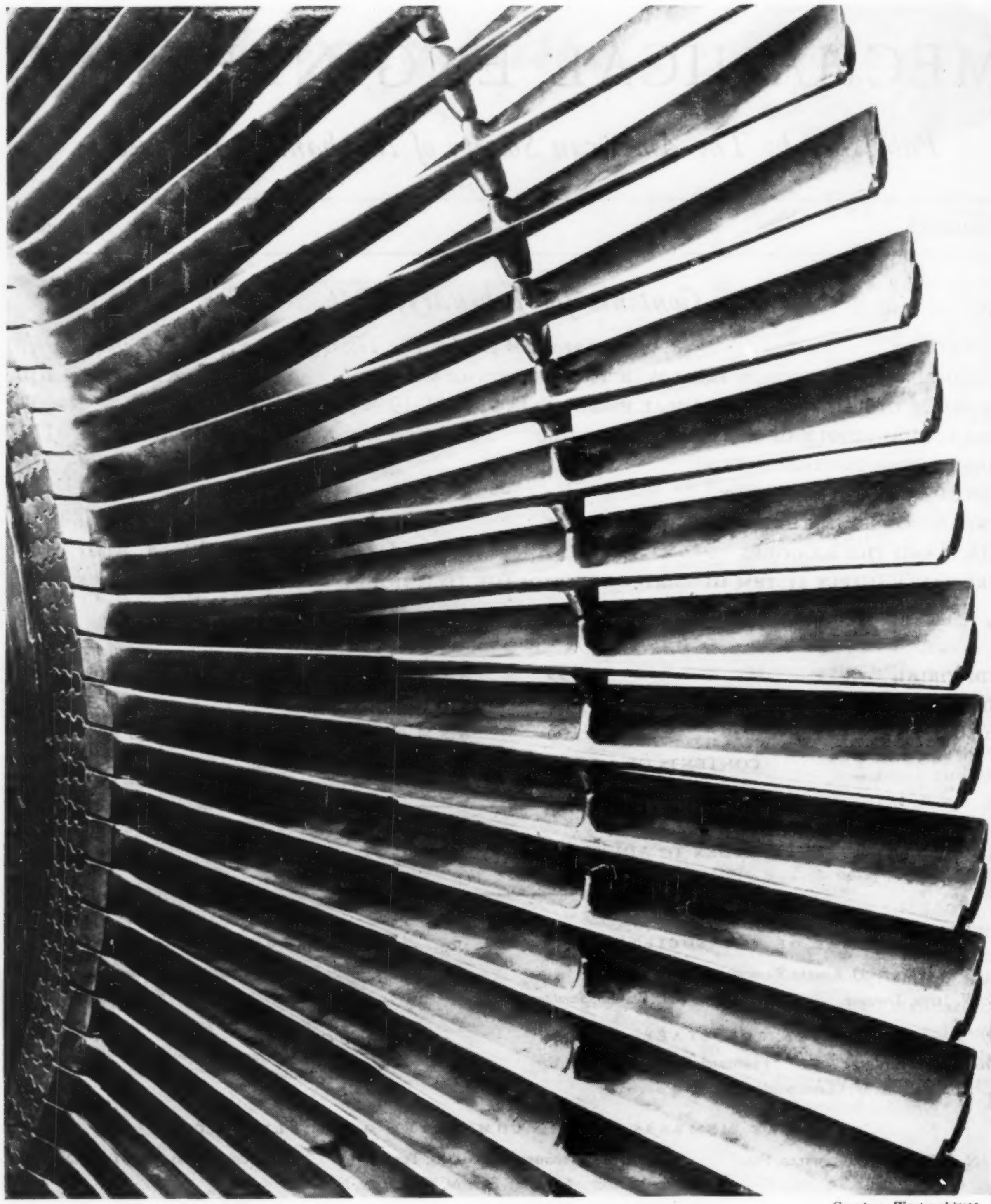

Courtesy Westinghouse

Forged Blade Lashing

(When turbine blades are assembled on rotor, the forged lashings are readily welded together without transmitting heat to the blades.)

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GEORGE A. STETSON, *Editor*

Scientists and Engineers

IN its issue of November, 1946, the de luxe magazine *Fortune* carried an article on the Radiation Laboratory at the Massachusetts Institute of Technology. During the war, what went on in this laboratory—the development of radar—was a top secret, and the *Fortune* article is one of these "now it can be told" reports, written in an interesting manner and playing up the adaptability of the "long hairs," that is, the physicists who made up the personnel of the laboratory, in doing developmental work.

It does not astonish the average engineer to learn that young physicists, whose principal interest would normally lie in fields of pure research, were able to carry on the developmental work in question, although work of that character is normally done in industry by other bright young men who are known as engineers. But the *Fortune* article and an editorial on the subject in the same issue make much of what the scientists accomplished, to the disparagement of engineers and their educational background. It would almost seem as though *Fortune* were seeking to embroil engineers and physicists in controversy that would be pointless and undignified.

There probably exists no group of men more critical of the educational experiences provided for and by their profession than engineers. There is probably no group of men who demand more insistently than do industrialists and engineers in industry that engineering education concern itself primarily with fundamentals. It is true that *all* engineering graduates are not as thoroughly grounded in fundamental science as they might be if they were a carefully selected group who expected to spend the major portion of their careers in the developmental laboratories of industries whose products are the result of new discoveries in science. But it is probably also true that a picked group of young engineers from these laboratories would show quite as much adaptability in pure science as did the physicists in developmental work. Such statements do not belittle the extraordinary feats performed at the Radiation Laboratory.

It would seem, therefore, that there exists not so much a controversy as a misunderstanding of the "functions of the scientist and the engineer and their proper relation to each other and to society." It will be profitable, therefore, to quote from a letter by an engineer who called our attention to the *Fortune* article. He writes:

The scientist's function is to explore and discover—the engineer's is to apply these discoveries for the improvement of society. The scientist is theoretical—the engineer must be practical. The scientist does not and should not concern himself greatly with the elements of "time" and "cost." Unless the engineer keeps these constantly before him, he fails in his profession.

The press of war made many expedients necessary. The entry of the scientist into the engineering field was one. The closure of research programs and the great shortage of engineers were responsible for it. Cost was no object. As to time, the scientist performed creditably, but remember, the race was a sprint. Now he can relax, but the engineer, returning to a peacetime economy, must continue the race against time all of his days.

Our colleges do and should attempt to prepare both scientist and engineer for their future lifework. For the scientist, mathematics, pure chemistry, and physics should be stressed to the utmost. The engineer is not in need of such intense preparation in these subjects, but he has need of preparation in the additional subjects of economics and psychology, and especially in the fundamentals of accounting, business law, and personnel relations. For these latter, the scientist has little need. In engineering work, higher mathematics is of little value in handling men, nor the intricacies of pure physics in planning a construction time schedule.

These [*Fortune*] articles placed great emphasis on the achievements of youth in these scientific developments. Apparently, our scientific ranks are being invaded by an increasing number of these prodigies who spring from our universities, as did Minerva from the brow of the great god Jupiter, "agleam in the full panoply of war, brandishing a spear, and with her war cries awaking the echoes of heaven and earth." In the field of engineering their initiative, vitality, and ability will be most welcome but they will not reach their full capacity until these qualities are tempered by time and experience. In particular, they must learn to respect the importance of "time" and "cost" in all engineering projects.

Restock the Libraries

IDEAS and knowledge are not easy for the individual to acquire unassisted, but once they take form they have a persistence and longevity that defy destruction. Time and again attempts have been made to destroy an idea by muzzling or putting to death the man in whose brain it was formed and to prevent the spread of knowledge by denying men access to it and by stealing or burning the books in which it is recorded. The Athenians sought to stop the mouth of Socrates by condemning him to drink the hemlock, but the thoughts he had uttered had gone forth and could not be recalled. They live today; and neither death nor years have silenced the man who said, "I cannot hold my peace, for that would be to disobey God." On clay tablet and on stone, on papyrus and on parchment, with chisel, pen, and printing press, men have recorded their thoughts. The

languages in which they wrote have been forgotten; time has ravaged and vandals have burned and obliterated records; but the dead languages are rediscovered, scholars piece together the fragments, the tales pass downward through the generations in verse and legend. The ideas multiply in active minds and are repeated and spread by hundreds of devices. No artificially created void can be made secure against the infiltration of knowledge or sufficiently sterile not to create or re-create the truth. Men who attempt to destroy or withhold knowledge succeed only in creating a stronger demand for it.

Throughout Europe, Asia, and the Pacific the destruction of war and the malicious mischief of would-be conquerors have destroyed or stolen thousands of books. Our fellow engineers in these countries face the task of rebuilding their cities and their economic life and are seriously handicapped by the loss of their technical books and by the dearth of recent engineering literature caused by the interruption of communications and transportation. The small portion of this loss which was represented by unpublished notes and manuscripts cannot easily be restored, but the greater part exists, thanks to the printing press, in considerable quantity for replacement. Publishers of technical books in untouched nations like our own will be able to provide current literature for engineers and institutions that have funds with which to restock their libraries. But where funds are lacking and books and periodicals are out of print the greatest source of available technical literature is in this country in the libraries of engineers and institutions that have little or no need for it. It is to these engineers that the Committee on International Relations of The American Society of Mechanical Engineers is making an appeal for technical books and periodicals with which to restock the libraries of countries devastated by the war.

The first step in the Committee's book campaign is to find out what books are available. Engineers who have technical books and periodicals to contribute are urged to send to the Society a list of titles, authors, publishers, and dates of publication. As soon as arrangements can be completed, shipping instructions will be sent. No books should be shipped until these instructions are received because distribution points will vary with the location of the donor and the library to be restocked.

Already the committee has received urgent requests for books from China and the Philippines and a special list of books needed in Czechoslovakia. It is hoped that each book can be marked with the name of its donor in order to personalize the gift in a manner that will emphasize the international good will of the engineering profession.

By restocking the libraries of the war-devastated countries the engineers of the United States, without loss of their own sources of technical knowledge, can vastly multiply sources in other parts of the world and quickly restore the means by which their fellow engineers may serve their people and frustrate the malicious intentions of those who thought they could destroy knowledge by destroying books.

"Science"

UNDER the editorship of the late James McKeen Cattell, *Science*, the weekly magazine which, since 1900, has been the official journal of the American Association for the Advancement of Science, had a long and distinguished career. Its convenient size made it easy to read; the selection of the leading articles it contained was broad enough to satisfy any person interested in science, either pure or applied; and its numerous departmental features served useful purposes. Brief items reporting scientific facts and techniques afforded research workers an outlet which was broad and timely, even though the titles of some of those notes were almost as long as the notes themselves and were quite mysterious to laymen or workers in other branches. Personals were always a source of up-to-date information. Obituary notices were frequently done in a manner to make the most accomplished writer envy the skill displayed. By and large each issue was a creditable job which readers of long standing approached with anticipation and laid aside with a sense of satisfaction. To MECHANICAL ENGINEERING, *Science* was a source of material for comment and quotation; in fact, many articles were reprinted from it for the benefit of engineers. Acknowledgment of this debt to *Science* and to Dr. Cattell has been long overdue.

With the issue of Jan. 4, 1946, *Science* appears under the editorship of Willard L. Valentine and in a format so closely resembling the former one that the reader experiences no distinct break with the past and suffers no shock of resentment which a too frequent straining for something new and different often causes. A new type face is used; the former self-cover is replaced by one of slightly heavier stock, although it remains conservative white paper; and the advertisement which used to adorn the cover has been replaced by a list of articles and features of the current issue. The moderation of these changes will probably win the approval of former readers.

Three pages of editorial comment on the changes instituted by the new editors serve as a preface to the first issue under their control. It is stated that the editorial policy will remain the same, "to try to present in as concise a form as is possible outstanding events of significance to all scientists, with an emphasis on those items that are of current interest." New features to be introduced are "Letters to the Editor;" a section called "Science Legislation," in which it is proposed to abstract "bills pending in the House or Senate which bear on any phase of science;" a book-review section, a "Scientific Book Register," and a "Catalogue Corner."

In the confusion of misunderstanding, vain hopes of what may be accomplished by science, impatience of delay, and the desire of demagogues to seize upon a popular trend for personal and political reasons, the clear voice of an informed authority is desperately needed. *Science* may well be that voice to which scientists and educated laymen will listen with respect. To the editors of *Science* engineers will wish to extend congratulations and encouragement.

ENGINEERING EVOLUTION *From* WAR *to a* PEACETIME WORLD

By L. K. SILLCOX

THE NEW YORK AIR BRAKE COMPANY, WATERTOWN, N. Y. FELLOW A.S.M.E.

LAND OF OPPORTUNITY

THE great American epic of the poor lad who wins fame and fortune through personal achievement and merit, self-sacrifice, and making his circumstances count toward his future has earned our nation a reputation as the land of opportunity. Countless men and women from all parts of the world have flocked to our shores seeking a chance for advancement. While many have doubtless been disappointed, the fact still remains that those possessing ability, vigor, and initiative have usually achieved their ambitions. To the extent that tales of greatness won against material odds are true accomplishments of deserving men and women, our nation experiences enduring greatness and a solid hope for the future.

Our young people, conscientious, ambitious, capable, and sincere, must never be denied the promise of advancement to the limits of their ability and effort. That is the essence of the way of life which has made our country what it is, and such a system has served us well. We must never think of exchanging it for a tax-supported, governmentally controlled and planned economy which would bring an end to all realistic initiative. The men and women who founded our nation believed that the government which governed least, governed best. In these circumstances, American business was unhampered and responsible; enterprise was free; and personal pride in accomplishment was an ideal.

The standard of living of our land is the wonder of the modern world. Nowhere else in the world do so many people live in such comfort and security. Not only are we possessors of the necessities of life, but we are also blessed with unsurpassed facilities which minister to daily life and afford luxuries beyond the power of the written word to describe fully.

Now we stand on the threshold of a new and truly complex postwar world. We must appreciate that by reason of recent governmental control of enterprise, resulting from gigantic planned war production, private industry is seriously endangered, and individual initiative and responsibility must be restored if we are to measure up successfully to our opportunities as a nation.

History has shown that when men slaved under the domination of feudal lords and were chained to the station of life into which they were born, little or no incentive obtained to carry out work more effectively or in a more satisfactory or economical manner than had been previously done. What incentive was there for the artisan of the middle ages to attempt any outstanding or original achievement when there remained absolutely no hope for him to benefit from his own endeavors? Thus mankind became a creature of fixed conditions over a long period of time, and this was the system which prevented human progress until a scheme was conceived whereby individual advancement could be attained and personal responsibility and resulting benefits secured.

Lecture presented at Bucknell University, November 16, 1945, and later in somewhat more expanded form at Purdue University on December 5, 1945.

We possess great traditions, traditions of which we are truly proud, traditions which must be upheld. Though we neither can wish nor possess the power to go back to the reality of the nineteenth century, we have the opportunity to realize its ideals—and they were not mean. We have small justification for feeling superior to our forebears. While perhaps they had not fully learned the ingredients for creating the world they wanted, the experience we have since gained should have equipped us better for the task of creating the world we desire. If we have failed in the first attempt to create a world of free men, we must try again. The guiding principle that a policy of freedom for the individual is the only true progressive policy remains as significant now as it did in the nineteenth century.

Industry accepts its responsibility to the public, to consumers, to labor, and to capital for making helpful progress possible in the future. If scientific experimentation in industry is continued we shall have widespread adoption of new productive processes, new resources, and still better standards of living.

THEORETICAL AND APPLIED SCIENCE

Today the growth of our modern industrial research laboratories, together with our institutions of technology, is closing the gap between scientific discovery and technological application. This was demonstrated by the development of the atomic bomb, an outgrowth of the comparatively recent science of nuclear physics. There was a time, however, when the science of physics preceded major technological application by half a century. The experiments on the fundamentals of electromagnetic induction carried on by Faraday, for example, preceded by about 50 years the development of the electrical industry; and radar in principle is of nineteenth century physics, coupled with the technology of the following century. Both radar and the atomic bomb resulted from planned programs of research utilizing established facts and principles; but science, strictly speaking, has, as a result of the war, advanced only moderately despite all of the great technical developments.

Radar at War. By rapid development of technological tools, the principle of radar had untold military applications during the war. Visually, radar possesses range advantages and penetration powers in darkness and poor weather, and in comparison with sound detection of aircraft, it has advantages of range and speed. Its range is restricted horizontally, however, by the curvature of the earth. While throughout the world there have been years of experiment in radar, it was in 1941, with the pooling of Anglo-American research, that a billion-dollar industry was built to meet the stern needs of offensive action.

Radar in Peace. Now in peace we are permitted increased information about the secret devices employed in war, as aircraft interceptors, ground-control approach systems, bombing through overcast, etc.; and now in peace we realize increasingly the unlimited uses to which radar may be put, for it promises to be the most significant advancement for increas-

ing safety in the history of transportation. Commercial airline pilots will land and take off in safety with a minimum ceiling of less than 100 ft; and in flight the terrain for several hundred miles around will be faithfully reproduced, in spite of the fact that the ground is blotted out by overcast. Collisions can be avoided in the air and on the sea.

Decca Navigator. In passing it might be of interest to mention another system, the Decca navigator, newly devised, for instantaneous and accurate indication of position, which is definitely not radar, however, nor is it based on the same principle. Reported as easy to operate as a domestic radio set, subject to no deviation of tides, winds, or polar attraction, and able to work in any position, it can be placed in any part of an airplane or boat. By simple reading of two dials, the navigator can learn his true position to within 100 yards at a location 300 miles distant from the controlling stations. (Incidentally the mine sweepers at Normandy on D-day were guided by this device.) Two transmitting stations send out long-wave wireless signals which by direct reading can be used by those with no previous knowledge in navigation or wireless, while radar uses short-wave-length impulses and requires highly skilled operators. Because of its simplicity, this device, developed in Britain, should have widespread application in air and sea navigation in the future.

Military Aircraft. Giant strides have been made during the war in improving aircraft. At the time of Pearl Harbor the engines of our military aircraft were rated below 1500 hp. Long before the end of the war thousands of supercharged engines with horsepower ratings of 2000 or more were developed, produced, and fighting on all fronts. Under favorable conditions of cylinder-head temperature and manifold pressure, the fighter pilot could add 300 hp to the engine's output by injecting water into the hot cylinder.

Not only were improvements made in load-carrying capacity as a result of increased power, but additional gun placements and fire-control mechanisms, etc., were added to the craft.

Aircraft Development. From fighter planes that before the war were developed for defensive interception which required but short flights of less than 2 hours, our aeronautical engineers have developed heavier, faster, and more maneuverable aircraft that are capable of sustained flight of 7 hours or more. New devices have accompanied the other improvements in aircraft as necessary accompaniments for their accelerated speeds, higher altitudes, and longer range of action, such as changes to the famous Norden bomb sight, and electronic controls developed for the automatic pilot. Most notable has been the engineering feat of producing over 100,000 planes annually. Mass production of aircraft has meant less costly planes with improvements in design effecting decreased operating costs.

While some of the technical advances made may not be applied to planes other than those for military use, the passenger-cargo types, such as the DC-3 and the DC-4, which were used successfully by commercial air lines before the war, will undoubtedly have improvements incorporated in them as air lines add to their postwar fleet. In connection with aircraft may be appropriately mentioned the expanded requirements for high-grade fuel which were successfully met during the war. About 8 years ago 100-octane gasoline was placed in commercial production to permit greater speeds and rates of climb, higher-altitude ceilings, and increased engine-power output. Since the war higher than 100-octane fuels are being realized, with important new processes and catalysts being devised.

The Gas Turbine. The development of the airplane and the steam turbine were apparently necessary experiences before the engineer was ready to tackle successfully the caloric-engine cycle, in the form of the gas turbine. While potentialities of this prime mover have, of course, been evident for many years, intensive engineering research has necessarily preceded their realization. New attention has been accorded the gas turbine since the war and while it must undergo further research before its future can be foretold, it does have a number of potential applications in view of its compactness, low initial cost, lightness per unit of power, and simplicity of operation and maintenance. Its use is dependent in part on the development of alloys resistant to high temperatures; and because of its rate of fuel consumption, research in this line will be desirable.

Turbines on the Railways. The turbine principle is being investigated by the railway industry, accompanying the refinements in design of the conventional reciprocating steam locomotive. The gas-turbine engine of Bituminous Coal Research, Inc., is in the laboratory stage only. Two triplex locomotives, a steam-turbine, electric-drive machine for the Chesapeake and Ohio Railway, and a steam-driven two-turbine direct-geared locomotive for the Pennsylvania Railroad, have appeared as artists' drawings, while a single-turbine direct-geared 6-8-6 type locomotive is in service on the Pennsylvania system and reportedly exhibiting highly satisfactory performance characteristics.

There are many features which make the gas-turbine cycle attractive for locomotive installation. Water treating and boiler inspection are thus eliminated for no water is used; a clear stack free of smoke at all loads results from the excess air; lubrication costs should not exceed 1 per cent of fuel costs; and vibration and maintenance are reduced by the rotary motion.

Turbines in Aircraft. Very recently the General Electric Company has announced the development of a gas-turbine engine for use in aircraft. Promoted under wartime pressure, the engine was designed to drive large high-speed military transports and bombers, and as far as is known, it is the first actual installation in an airplane.

A number of other companies are being credited with advanced models, but as yet no details have been released as to size, power, cost, or time of availability for commercial aircraft.

According to the General Electric announcement, there is some jet effect as well as utilization of a propeller, and while this propeller-type installation will not attain the extreme speeds of pure jet, it will operate at speeds close to that of sound, with greater economy than that of the conventional reciprocating engine. In the General Electric installation the turbine revolves at 10,000 rpm and operates in excess of 1500 F. The propeller is driven through a reduction gear, and the compressor which is of the axial-flow type is in the center of the engine.

Jet Propulsion. Propulsion by jet followed the wartime development of the gas turbine as a more or less natural sequence for the airplane because for the first time, circumstances were right for the application of this simple idea. Jet propulsion of planes probably will have profound influence on the future development of aircraft, particularly in respect to the factors which determine economical speeds and altitudes. Even if jet propulsion should remain limited to military purposes, it is generally believed that turbine and propeller drives are certain to play an important role in the aircraft of the future.

While the impetus of war, which is no respecter of economics, stimulated interest in jet-propelled aircraft, many authorities feel that its development may not be great enough for many years to come to have a very marked effect on aviation, in spite of its advantages of speed, freedom from vibration, quietness, and simpler operation. While at altitudes of over 50,000 ft it might exceed the efficiency of the conventional propeller type, its extremely high fuel consumption would appear to prohibit commercial usage in the near future.

WARTIME PRODUCTION PROGRESS

Technical advance has been impressive during the past four years, when we have devoted every effort to making America the "Arsenal of Democracy." The utmost was produced in the minimum of time, short cuts were sought, and expense was necessarily ignored. At the outset the procedure was expensive but through mass production and accompanying improved techniques, in many instances costs were pared drastically and automatically, a logical outcome when, in order to meet the severe demands of war, the most efficient use possible was made of manpower, methods, and materials. It was necessary in many cases to use unskilled labor on work calling for the highest degree of perfection.

Thus technical application of electronics, for example, was made in every conceivable place, with electronic-flow detectors accomplishing their work rapidly, automatically, and accurately. Closely related to this was the evolution in methods, resulting, for instance, in the development of inspection techniques with widely varying applications. Then there was the excessive demand made for certain materials, and the consequent research devoted to finding substitutes.

Electronics in Industry. In connection with the technical application of electronics just mentioned, hundreds of devices have been developed or improved. While for many years the electrons served in closed circuits, when they were finally liberated and controlled their science began, with the electric eye being the simplest and oldest of all the electronic tubes which now number over seven hundred. In metal work, among many devices which might be mentioned, there is the automatic dew-point recorder, invented by Westinghouse, capable of detecting the presence of 0.004 per cent of water vapor in the gases of heat-treating furnaces—important when one realizes that a few moments' exposure to wet gas could ruin a quantity of machined parts; there is the spectrograph analysis employed by the Aluminum Company of America, which identifies component elements in samples of aluminum and has proved effective in determining, for example, the composition of aircraft tubing without damage to it; another device reported in *Modern Industry* for determining the size of metallic powders has reduced the time of testing from 8 hr to 15 min; and finally, there is an electronic device which detects imperfections in metal strips and marks sections where these appear for rejection and, further, can automatically throw out defective metal sheets by utilization of an energizing control.

Electronics in Photography. In the field of photography there is, among other devices, the electron microscope, important in biological and industrial research, making possible visual magnifications as high as 30,000 diam and photographic magnifications of more than 100,000. Through this device the influenza virus has been photographed, important discoveries have been made in synthetic-rubber research, and innumerable other applications have been developed by which the range of research has been extended.

General Electric has developed a high-speed electronic light unit enabling photographs to be taken with an exposure of only 1 microsecond or 33 times as fast as other high-speed photographs of recent years. High-speed machinery has been photographed, and still photos have been made of a wheel revolving at 70,000 rpm. Obviously, these are but representative of the many applications which have been made in electronics.

METALWORKING PROGRESS

Because of the nature of war production, attention given to procedures and methods was largely concentrated on various aspects of metalworking and consequently, considerable advance was made in techniques such as welding and riveting, powder metallurgy, casting, and inspection procedures.

Shipbuilding, aircraft, and heavy ordnance work were largely responsible for the expanded requirements of riveting and welding. In riveting, the development of automatic bucking bars and automatic guns both expedited the work and made it simpler for beginners. In welding, particularly because of its adoption in so many instances as a substitute for riveting, new practices were inaugurated for speedier and more accurate work. For example, improved automatic welding machines moved either the guns or the work to ordered positions, then made several simultaneous welds. Mentioned under magnesium is the new Heliarc process, applicable to various metals and capable of welding thinner sections of stainless steels than was formerly possible.

Research work in welding moved steadily and rapidly forward during the war, with such end results as the familiar all-welded ship with its incredible production record. Nor has quantity alone been the only outcome, for through new or perfected welding practices nearly all of our weapons of war have been improved, among other things, tanks of less vulnerability, artillery of greater maneuverability, planes of higher speeds, and vehicles of less dead weight.

Through partial removal of power restrictions effected by utilization of stored energy and pulsation welding, resistance welding can be expanded to the joining of heavier parts and assemblies of metals, both ferrous and nonferrous. Research in welding carried on during the war amply justified the expenditure of several million dollars, which in part was furnished by the Federal Government.

Furthermore, both speed and effectiveness, as well as better products, have been realized in the new procedures of heat-treatment, employing timing systems, automatic conveyers, electric induction heating, and various other developments.

Through improved fabrication processes such as powder metallurgy and centrifugal casting, machining time has been reduced; continuous casting has cut down intermediary steps with consequent reduction of labor and scrap.

QUALITY CONTROL

Quality-control techniques in ordnance inspection were necessarily developed, for a large portion of the material manufactured in mass production called for a degree of perfection which had been uncommon in much industrial work in the past. Mechanical gaging and photoelectric-cell gaging were introduced wherever possible to eliminate inspection fatigue; but even these substitutes for manual inspection have their margins of error.

Through quality control, attention is focused on unfavorable conditions before they would ordinarily be evident, and thus an early start is made in tracing the causes of difficulty. Testing equipment, time, and material are conserved, and quantities of defective material are thus eliminated.

SYNTHETIC RUBBER

Because of the great demand for certain materials vital in munitions production and combat operations, and because in many instances our normal supply was shut off, it became necessary to concentrate on substitutes. While synthetic-rubber research began as early as 1860, not until recently have satisfactory commercial products been developed; and now it is safe to say that as an engineering material with definite engineering application, synthetic rubber is here to stay. Nor should it be considered solely a rubber substitute by any means, but rather an essential engineering requirement, for synthetic rubber is proving to be superior to natural rubber in certain specific applications. Tabulations indicate the superior status of one or more of the present synthetic rubbers as compared with natural rubber in regard to over twenty vital properties, such

as resistance to swelling caused by mineral oils, gasoline, and other solvents; resistance to cracking from flexing; heat-aging resistance, etc.

Now that the war is over, engineers anticipate further improvement in compounding technique and development of new synthetic elastomers. At an S.A.E. meeting held early in the year, the thought was expressed that the present synthetic-rubber progress is probably the greatest organic-chemical engineering project ever attempted in our country and perhaps in the entire world. New types are constantly being developed, and while they are comparable to or exceed natural rubber in some properties, quite generally they are inferior to it in others; their use being confined to applications in which particular specifications are appropriate. However, it is certain that its role will be important in engineering practices and procedures in the future.

DEVELOPMENTS IN PLASTICS

Increased use of plastics has been stimulated by the needs of war, not only, as in the case of synthetic rubber, as substitutes for critical materials, but for their own unique and valuable properties. True plastics are synthetic materials which it is possible to cast or shape and then to cure in a more or less rigid permanent shape. They contain an organic binder and usually a filler. Particularly important are molding powders which ordinarily contain filler to impart specified properties.

There are many varied types of plastics with specific physical characteristics and uses, such as phenolics with ease of molding; resistance to heat, solvents, and chemicals; low cost; used particularly for electrical insulator parts, distributor heads, radio-tube bases, housings, containers, and the like.

Progress in Plastics. During the last year the outstanding advance in the plastics industry was in the development of high-frequency preheating equipment with its employment to speed production and resolve problems of heavy-section molding. Through heatronic molding of industrial parts, curing time has been drastically reduced with savings in machine hours and manpower. No doubt, now that the war is over there will be many new applications of plastics, and the technical progress which has characterized this industry will probably continue.

It is a fact, however, that the future of the plastics industry will be dictated by factors of economy, and while the price per pound of most plastics is higher than that of the metals with which they are competing, there will remain applications in which plastics are highly practical because of savings in fabrication time and cost, or because of special properties not attainable elsewhere.

NATIONAL EMERGENCY STEELS

The development of the National Emergency series of steels was prompted by the critical shortages of such alloying elements as nickel and chromium. Before their introduction careful investigations of the physical properties of the new materials were required, investigations that were markedly accelerated by the application of the Jominy "end-quench" method of determining hardenability.

Indications are that certain of the N. E. steels will remain in use long after the end of the war, since they have demonstrated that high-strength alloy steels may be produced with efficient use of expensive alloying elements. Product designers in the next few years will necessarily study with great care the materials developed.

Plywood. Plywood is another item which has been improved and widely used during the war in housing units for soldiers overseas, and in aircraft, marine, and railway construction. In the latter, plywood-sheathed boxcars have been constructed with a weight saving of about 1800 lb per car over those of conventional steel sheathing. In this manner it is possible in many instances to realize heavier pay load, still keeping within the axle-loading limits established by the Association of American Railroads.

The developments of the Vidal process for maintaining uniform pressure on assemblies during curing; high-frequency electrostatic heating for bonding of thicker assemblies; and increased application of synthetic resin for permanent bonding have all been important in the last few years. Plywood with its lightness, good insulating characteristics, and high structural strength, can now be made flame- and weather-resistant, and in all likelihood it will have expanded peacetime uses.

Magnesium and Aluminum. The same might be said of magnesium and aluminum. Progress is steadily being made in alloying, casting, and forming magnesium, with the new Heliarc welding process being applied to this metal as it is to others. It is 35 per cent lighter than aluminum and although not corrosion-resistant, it is being used to advantage in transportation equipment, for when alloyed, it possesses great strength. The production capacity of magnesium has not been developed to the point of that of aluminum, thus its future is to a degree dependent upon technological progress.

The production capacity of aluminum has also undergone considerable expansion with new methods enabling recovery from lower-grade ores not previously worked, and the application of new manufacturing techniques. The choice between using aluminum and magnesium will depend on the importance of corrosion resistance of the former and the superior lightness of the latter; also, governing their use will be their relative prices which will depend in part upon the further development of extraction techniques.

It is generally anticipated that more aluminum will be used for transportation equipment than was true before the war, particularly in the railway industry where, in replacing obsolete locomotives and cars, substantial amounts of aluminum alloys may be employed in the new equipment. Also it is possible that aluminum will be used to a greater extent in foundry and metalworking equipment.

Aluminum is readily processed, is light, has a permanent surface finish, and is capable of being rolled, stamped, sand- and die-cast, forged, spun, and extruded. Its parts can be joined by several methods of welding and riveting; or with other aluminum, wooden, or plastic parts, it can be joined by thermosetting plastic adhesives. While its use will be contingent on the price adjustment to that of competing materials, at present the technical knowledge which makes aluminum more easily fabricated for a variety of purposes insures extensive application.

Contributions to Medicine. As is usual in war, advances have been made in medicine, particular publicity having been given the sulfa drugs and penicillin. Introduced into the United States in 1937, sulfanilimide, now used mainly for local infections, was the forerunner of other sulfa drugs and their derivatives. Discovery of penicillin was made in England in 1929, but not until 1940 did its therapeutic value receive wide publicity. It is of particular interest from an engineering point of view because of the large-scale production program undertaken two years ago in Canada and the United States, involving the construction of nearly twenty plants.

There is much critical equipment required in its manufacture, such as centrifuges and refrigerating machinery, and research is being constantly undertaken for improvement of production processes and packaging methods. The latter is a serious problem because of the instability of the drug.

A still newer drug is the streptomycin, serving purposes which neither sulfa nor penicillin can, and which appears to be

a mighty weapon against a great variety of diseases—typhoid fever, cholera, surgical infections, and perhaps tuberculosis. Undulant fever has been successfully treated, and Bang's disease, costing farmers some $30,000,000 annually, can be abolished. Merck and Company is building a $3,000,000 plant to produce the drug, a manufacturing process which is as problematic as that of penicillin. It will be at least a year before the drug becomes generally available, however, and it will be expensive.

Important, too, in the control of insect-borne disease, has been the introduction into this country of DDT, rated as the most effective insecticide yet developed. It was used extensively by the Armed Forces, and already it is proving to have great peacetime demand.

PROCESSED FOODS

Dehydration. Great impetus was given to new food-processing methods during the war when it was necessary to transport and store huge quantities of food for our men and our allies. Shipping space was at a premium, climatic conditions were varied, and above all was the desire to see that the members of the Armed Forces received the best possible nourishment.

Dehydration was greatly expanded to include vegetables, fruit juices, and meats, in addition to the commonly dehydrated milk, soup, and eggs. Generally speaking, 1 lb of dehydrated product may be obtained from 10 lb of fresh vegetables, 3 dozen eggs, or 4 lb of raw meat.

There are numerous steps preparatory to dehydration, and particularly in the case of vegetables, it is important to locate the dehydrator near the source of supply to prevent deterioration after picking. For the most part, dehydrators are of the countercurrent, forced-draft type, with the trays of prepared foods moving in a direction opposite to the current of air. Naturally the processes of dehydration vary with the products being prepared.

In order to minimize shipping space, dehydrated foods are compressed by pressures ranging from 250 to 2500 psi, the temperature, pressure, and time of compression being adjusted according to the kind of food. Generally speaking, best quality is obtained at lower temperatures, and theoretically, vacuum-drying is preferred. However, commercial application will not be immediate because of the high initial expense and operating cost of vacuum driers.

Quick Freezing. Quick freezing of fresh foods has also advanced rapidly, and it is anticipated that precooked dishes will soon receive considerable demand.

The food-freezing industry was nearly doubled in size and output during the war, with over 550,000,000 lb of fruits and vegetables so prepared last year. This does not mean that all the problems attending food freezing have been solved. For example, 50-lb packages (baker size) of fruit may suffer outside spoilage while the center is still not thawed.

A chain store has devised a dielectric unit which defrosts a 30-lb carton in 15 min instead of 70 hr, practical for bakeries and hotels, but too expensive for home use. Obviously, there are many industrial difficulties regarding better methods of freezing, packaging, and defrosting yet to be resolved.

DEVELOPMENTS IN UTILIZATION OF ATOMIC ENERGY

The Atom in Wartime. The spectacular utilization of atomic energy in the war has been widely discussed and copiously written about, yet most of us hesitate to speak authoritatively on a subject of its magnitude. The atomic bomb has altered the outlook on armament races which in the past have always had two aspects. If someone were to build bigger guns, for instance, he could also provide heavier armor plate for his ships, in anticipation of the bigger guns of his competitor. In short, it has always been that there was a new defense against each successive weapon of attack with a sort of balance obtained, whereby in the end, war remains possible as a contest of force, frequently considered advantageous by a power that believes it has out-armed another rival by a safe margin.

There is reason to believe, perhaps, that warfare with atomic bombs could be conducted with the same expectation of successful defense. Yet the scientists who have lent their knowledge to industry and to the Armed Forces express the conviction that no defense against the weapon of their creation is possible, at least at present. If they are correct, it little matters whether a nation has 2 or even 10 times as large a supply of atomic weapons as another. If 40,000,000 citizens can be killed in one single raid, as has been testified, an attempt at security by armament immediately becomes senseless from the point of view of the most cynical considerations of efficiency, and aside from political, moral, and ethical issues.

What, then, can we do if it is true that no safety can be secured by military preparations, and if we have to admit that, as a consequence of the availability of this superweapon, the military has been rendered useless? The problem leads inevitably to the necessity of a world-federal control if we are to survive in the future.

The Atom in Peacetime. Dr. Arthur H. Compton, Chancellor of Washington University, St. Louis, Mo., chairman of the National Academy of Sciences committee on the use of uranium in war, and director of the metallurgical project which initiated research on the atomic bomb, has explained that atomic-power units cannot be built weighing less than 50 tons, inasmuch as a massive shield of at least 2 or 3 ft of solid steel must encase the atomic unit to prevent dangerous radiation. Ships and power plants are two applications for such heavy units, but obviously, driving cars or airplanes of ordinary size by atomic power are ruled out.

Numbered among the advantages of atomic power are an extremely slow rate of fuel consumption and consequent low cost of fuel, wide flexibility and easy control of the rate at which power is developed, and the absence of smoke and noxious fumes at the power plant. It has been expressed by scientists working on atomic energy, that following adequate research, atomic-power plants will be able to compete with coal-consuming plants in respect to cost. However, until much more is known about nucleonics, supervisors familiar with radiological hazards would be necessary to direct the service and operation of atomic-power plants.

Possible Atomic Restrictions. We know what this newly utilized source of energy has done, but we do not yet know exactly what it will lead to in peacetime. We realize that there are many factors which may restrict its use, such as governmental restrictions; the supply of uranium; the ineffectiveness of large piles using normal U-235 concentration (such as the Hanford piles which are inefficient in the sense that shutdown must be effected after a small portion of the U-235 has been consumed); the high cost of concentrated U-235 for smaller, more effective piles; the danger from radioactivity; and the weight and cost of shielding against radiation. In spite of these and other factors, we know that research will go forward, for it is not in the nature or spirit of man to stop once he has unlocked one more of the mysteries of science.

ACCELERATED ENGINEERING DEVELOPMENTS

In the limits of a paper of this nature it would be impossible to cover the many ramifications of the role of engineering during the war. The most that can be done is to touch upon a portion of the high lights. We do know that few of the war-

time developments were completely new or attributable to any one person or organization. The war did, however, accelerate the pace at which certain advances were made, and we hope it stimulated mobilization of our best in the way of natural and capital wealth and skill. Certain technological developments which were responsible for effecting efficiency in our industries should be continued, and research should go forward in developing new materials, for the war has indicated that any nation, regardless of its natural resources, may make almost anything.

New materials call for new production and fabrication methods, and the appearance of new products encourages investment in new enterprises and, consequently, serves as the foundation for an expanding economy. To the extent that we can efficiently integrate wartime developments with our economic system, our standards of living will be improved. The pace of this integration, however, will depend to a great extent on the general level of economic activity.

ECONOMIC PROBLEMS

There are problems of slums and strikes and innumerable other factors which are impediments to a completely healthy economy. Certainly the absence of high employment alone cannot be held responsible for conditions to the contrary. Yet it can never be considered excusable that our fellow men should be living in need at a time when natural and capital wealth and manpower are lying in idleness, and every effort should be made to guard against sweeping oscillations in the business cycle.

Business depressions and their prevention are a fundamental economic problem. Employment can be considered satisfactory when sales keep pace with effective business capacity. Nor does lack of demand imply that private business is unable to produce more efficiently than government. This keeping of sales consistent with effective productive capacity signifies the free-enterprise system in which business will be responsible for provision of jobs and goods, while government should create conditions of prosperity which assure markets for capacity output.

Basic Responsibilities. By stressing that the goals of full employment and a high level of business sales are paramount to our aims, we imply that producers must prove their usefulness in the market and that government must be sure that economic conditions are favorable. There are basic responsibilities involved in the achievement of a reasonably high level of sales and employment, for not only is it necessary for producers to fill the needs of consumers, but for workers to adjust themselves to the needs of the job. It cannot be expected that the government can establish an economic situation in which there are available markets for useless goods or opportunities for unadaptable individuals.

Maintenance of economic stability must necessarily be the government's task, for both the large and the small individual enterprises are helpless when a depression sweeps the land. The government should, however, carry out its responsibility within the framework of a free-enterprise system, which, unguided in the past, has made its advances by alternating periods of booms and depressions. The profit motive is admittedly the guiding factor in business, and to expect business to assume social responsibilities at a time when there are neither markets nor jobs is unreasonable.

Therefore it is for both government and business to do their share as well as to be receptive to each other; and the individual, too, has his obligation of anticipating demands and of developing his employability—for surely a proficient worker is more employable than his untrained or poorly trained brother.

Preservation of Incentive System. There is growing alarm over trends which may jeopardize the American incentive system, and some of our leading scientists are warning Senate committees that if these trends are continued, our country may lose its leadership in scientific research. The charge that the spirit of pioneering is becoming extinct in America is a serious one; but we know that it does not have to become a fact, unless we put security before incentive and opportunity. Russia intends to carry out a program of research greater than that considered by any other government. But let it be noted that she has revised her system to include one of the best features of our capitalistic system, "incentive," nor does this apply only to pieceworkers, but to scientists as well.

NATIONAL RESEARCH FOUNDATION

In this connection might well be mentioned the studies which are being made for the creation of a scientific research agency in our country. In July of this year, Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, prepared and submitted to the White House a report recommending the establishment of a National Research Foundation. This is only one of many reports which have been introduced on the subject; but in the interest of brevity, and because of the widespread interest which it has aroused, discussion will be confined to Dr. Bush's study.

His plan is that Congress create a foundation authorized to place contracts for scientific research, to make grants providing for fellowships and scholarships, and generally speaking, to develop and promote a national policy for scientific research and scientific education. The purpose is stated to be "to support basic research in nonprofit organizations, develop scientific talent in American youth, and support long-range research on military matters."

He advises that the director be chosen by a committee of nine members named by the President on the basis of their interest in and capacity to promote the purposes of the foundation, who are not otherwise connected with the government, nor with any special interest.

As to industry, Dr. Bush believes that the government should provide suitable incentives for research by clarification of present uncertainties in regard to the deductibility of research and development expenditures from net income, and by strengthening the patent system, in order to eliminate uncertainties now bearing heavily on small industries.

Throughout Dr. Bush's report the place of the university, the laboratory, and the individual is given due recognition, with an underlying purpose being the encouragement and assistance to scientists, potential and arrived, at the same time providing well-trained recruits for depleted teaching and research staffs.

Whatever the outcome of the government's role in future research, legislative action which would culminate in political control of scientific endeavors should be carefully guarded against; and the work of individual scientists and scientific organizations should go forward. The problem is not an easy one—for while science must be free, yet there must be a kind of co-ordination of scientific enterprise, public and private, that wasted effort may be avoided and that our independence in fundamental research may be established—always without curbing or dominating universities, foundations, or industries.

THE ENGINEER'S RESPONSIBILITY

In this discussion of a scientific research agency is implied the desirability, even necessity, of a policy consistent with our peacetime democratic procedures of nonviolation of the free-

(*Continued on page 138*)

PROGRESS *in* RAILWAY MECHANICAL ENGINEERING[1] 1944–1945

THE year 1945 was one in which a number of factors combined to cause unusual activity in the field of railway mechanical engineering. Speaking particularly of motive power, for almost the entire period of the war the railroads were kept too busy trying to meet the demands of operating departments for power and equipment to devote very much time to the development of new ideas, except as they pertained to the use of equipment. Strangely enough, the very process of trying to get more and more out of existing equipment served to amplify the shortcomings of much of the older equipment as well as the advantages of the new. It was during these years when both motive power and rolling stock were being utilized far beyond the prewar expectations of most railroad men that the way to future improvement of cars and locomotives was being pointed out.

The Diesel-electric locomotive, whatever its disadvantages may be, did a remarkable thing for the good of the railroads, namely, it made them conscious of the value of utilization, and the relation of trouble-free performance to maximum utilization. It made them conscious of the value of capacity, especially capacity in economically flexible form. In short, in the field of motive power it made the railroads realize what must be done to improve existing types of equipment. Furthermore, it focused attention on the fact that industrial developments, particularly of the war period, had opened up a whole new world of opportunities for the adaptation of new types of power applications to the job of hauling trains, and had done so at a cost that can put the roads in a position to compete on a favorable basis with other forms of transportation in the postwar period.

For the benefit of the engineer, it may be well to call attention to the fact that in any discussion of railroad motive power it is not too difficult to become so absorbed in a study of engineering refinements of existing equipment that one loses sight of a factor of paramount importance in railroad operation, i.e., that the job of a railroad is one of hauling tons of freight and thousands of passenger cars over varying distances and under all kinds of conditions and doing it at a profit. It matters little if engineering achievement results in a locomotive that, for instance, has a thermal efficiency representing a substantial increase over any of its predecessor designs if the cost of building or of operating and maintaining such a power plant is such that its over-all cost relationship to traffic shows up poorly. The measure, in freight service, of motive-power-performance cost is, after all, cents per thousand gross ton-miles, and in passenger service, the cost per passenger-train car-mile.

The Diesel-electric locomotive and the modern steam locomotive of high boiler capacity, completely equipped with roller bearings and mechanical pressure lubrication, have set performance records and cost records on these bases that are going to require real engineering development work to improve. The steam-turbine, the turbine-electric, and the gas-turbine locomotive—all developments of the future—have not only to compete with the improvements in existing motive-power types that are sure to come but have to be developed in themselves to a point where they can take their place in the everyday job of railroading on a favorable cost-relationship basis.

In appraising the presentation, in this report, of the past year's progress in railway mechanical engineering, it will be well to keep in mind that progress in so vast a field of endeavor must, of necessity, be slow and that the only test of the value of a development in the railroad field is the test of many months—sometimes years—and millions of miles of service. If it can do this at a profit in the production of transportation, it is a worth-while contribution.

DOMESTIC STEAM LOCOMOTIVES

The past year has seen relatively few new steam locomotives built for domestic use. The Diesel-electric has practically captured the new switching-locomotive field and is making appreciable strides in the road-locomotive field. Indicative of this trend is the fact that by mid-year (June 30, 1945) there was a total of 3202 Diesel-electric locomotives in service on domestic railroads. Of these, 2560 were switching locomotives, while the remaining 642 were for road, freight, and passenger service. During the first six months of 1945, a total of 132 road locomotives were placed in service. A few of the smaller roads have displaced steam motive power entirely with Diesel-electric equipment, while some of the larger roads are moving to install Diesel-electrics exclusively for the operation of some of their more important divisions.

Steam-locomotive proponents and those roads vitally interested in coal as a motive-power fuel as well as a source of revenue tonnage have not been idle in improving the performance of coal-fired steam locomotives.

Indicative of the advancements made in the design of modern steam locomotives are the test results obtained with the 4-4-4-4-type Class T-1 locomotives built by The Baldwin Locomotive Works in 1942, for the Pennsylvania Railroad. A brief description of these engines appeared in the 1941–1942 report.

These locomotives were designed to haul a trailing load of 880 tons at 100 mph. In road tests, they have considerably exceeded this requirement, having hauled trailing loads of approximately 1000 tons at better than 100 mph.

During performance tests, conducted at the railroad's test plant at Altoona, this locomotive developed 6552 ihp at a speed of 86 mph. A minimum water rate of 13.6 lb per ihp-hr was obtained with a 20 per cent cutoff at a speed of 76 mph and an output of 5535 ihp. For all other tests the water rate varied between 14 lb and 15.5 lb. The mechanical efficiency was above 90 per cent at all speeds, and horsepowers, with a high of 97.5 per cent at 38 mph and 4500 ihp.

At low and moderate horsepowers, the dry coal fired

[1] Report of Committee RR-6, Survey, Chairman, H. C. Wilcox; members, B. S. Kain, E. R. Battley R. P. Johnson, and K. F. Nystrom.
Contributed by the Railroad Division and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of The American Society of Mechanical Engineers.

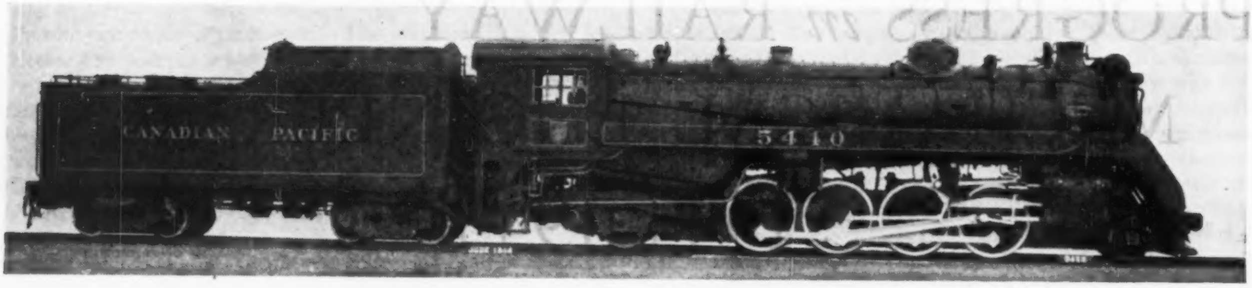

FIG. 1 A 2-8-2 FOR THE CANADIAN PACIFIC

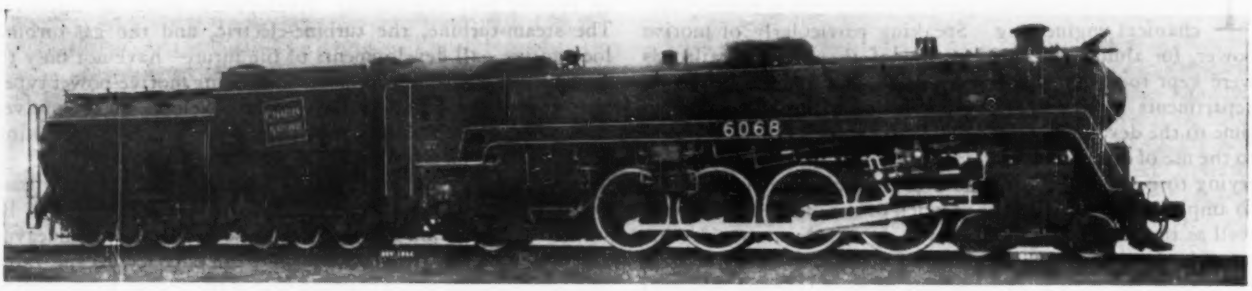

FIG. 2 A 4-8-2 FOR THE CANADIAN NATIONAL

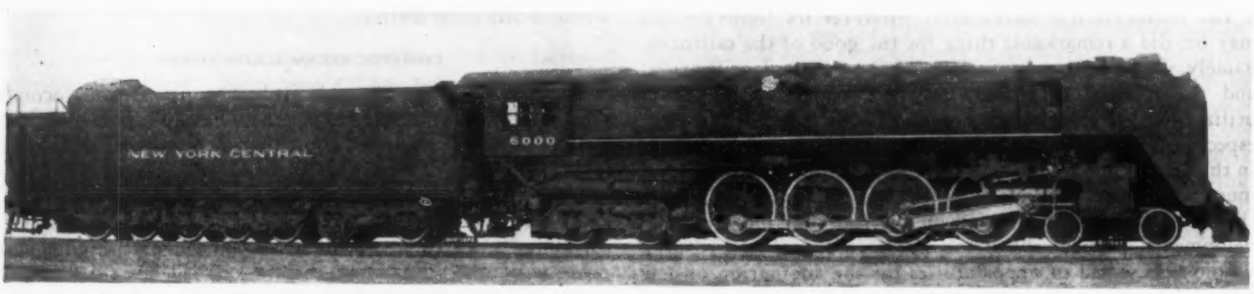

FIG. 3 THE NEW YORK CENTRAL S-1a FOR FREIGHT AND PASSENGER SERVICE

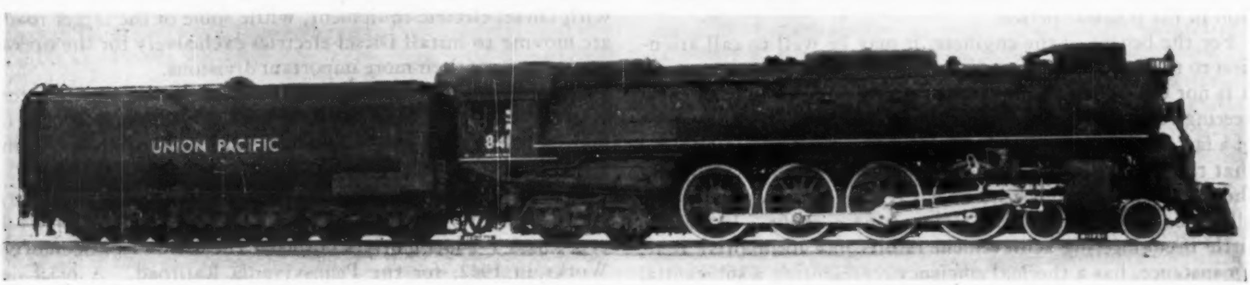

FIG. 4 4-8-4 FOR THE UNION PACIFIC

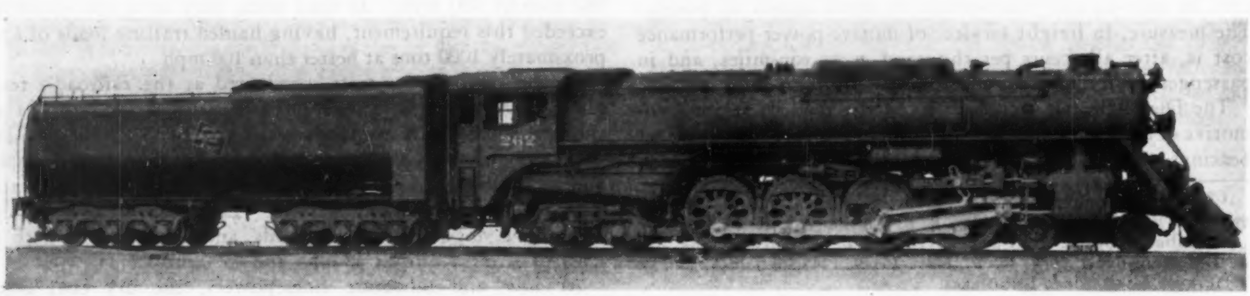

FIG. 5 4-8-4 FOR THE MILWAUKEE

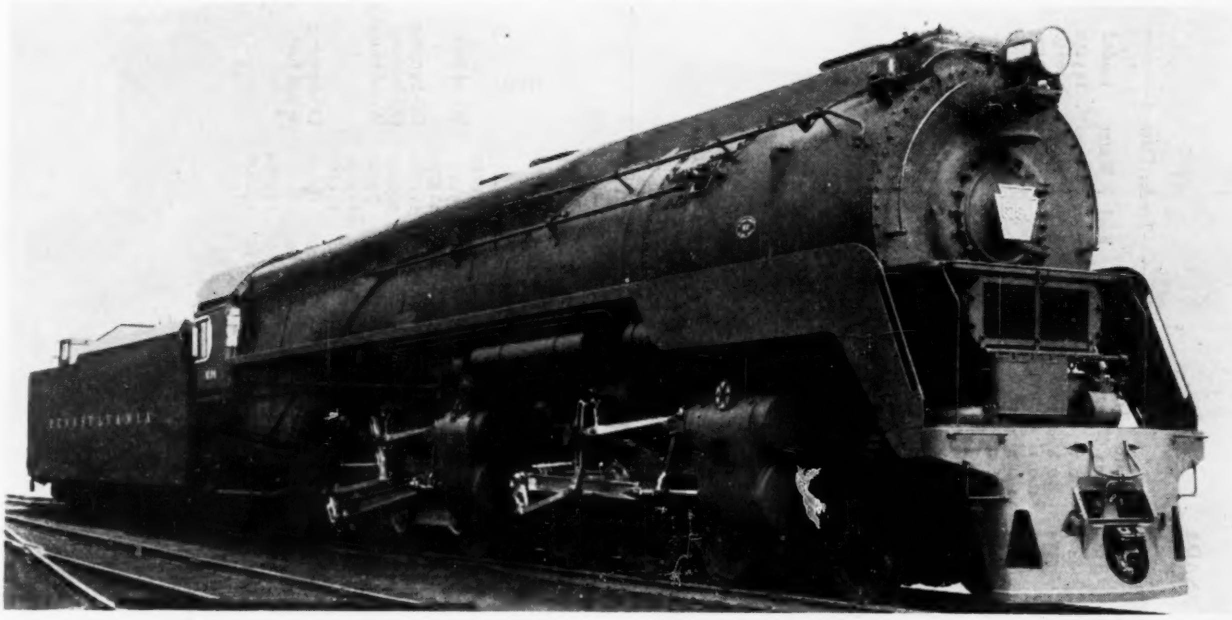

FIG. 6 THE PENNSYLVANIA CLASS Q-2 NONARTICULATED FOUR-CYLINDER 4-4-6-4 LOCOMOTIVE

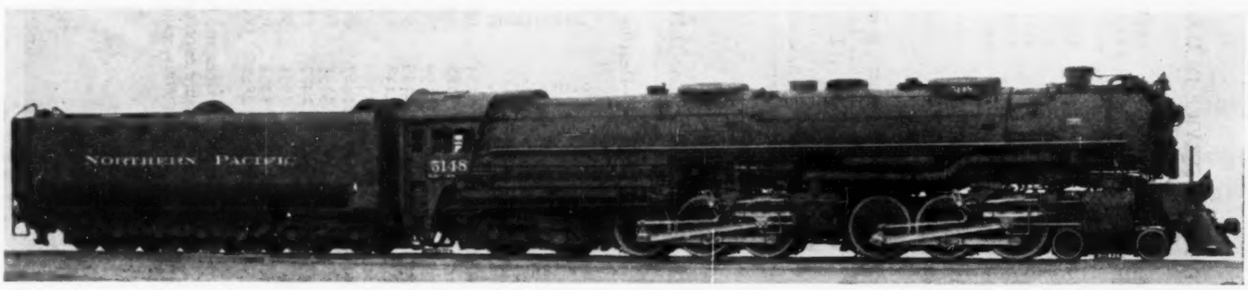

FIG. 7 SIMPLE ARTICULATED 4-6-6-4 FOR THE NORTHERN PACIFIC

per drawbar horsepower was generally below 2.5 lb. From 5500 drawbar horsepower to 6000, the coal rate rose from 2.5 lb to about 3.5 lb.

A maximum evaporation of 105,475 lb of steam per hr was obtained at a firing rate of 23,000 lb of dry coal per hr. This corresponds to an evaporation rate of 25 lb per sq ft of evaporative heating surface per hr.

Steam temperatures leaving the superheater reached 800 F and were generally between 760 F and 800 F, during all high-capacity tests.

It is believed that the foregoing attainments stamp this locomotive as one of the outstanding designs of this day. To develop over 6500 ihp, evaporate water at the rate of 25 lb per sq ft of heating surface, attain steam temperatures of 800 F, water rates around 15 lb, and to ride comfortably at 100 mph while hauling 16 cars, is so outstanding a performance as to warrant the interest of all railroad men.

Two locomotives built in Canada for Canadian railways are shown in Figs. 1 and 2, and described under items Nos. 1 and 2 of Table 1.

A notable 4-8-4 locomotive made its appearance in the S-1a class built by American Locomotive for the New York Central System. Since this locomotive was an experiment, but one was built initially and this was arranged to use either 75-in. or 79-in. drivers. Service tests on the experimental unit indicated the soundness of its design and 25 additional duplicates with some changes are in the course of construction at this writing. Characteristics are shown in item 3 of Table 1, and the locomotive is pictured in Fig. 3. A noteworthy feature of the design is the absence of a steam dome, a departure from normal practice made necessary by the fact that the boiler comes well up to the clearance limits. It is expected that the locomotive will develop not less than 6000 ihp. Worthy of particular mention is the tender with a relatively nominal water capacity of 18,000 gal, but an exceptionally large coal capacity of 46 tons. These fuel and water capacities in conjunction with track pans and a large ash-pan capacity (86 cu ft) combine to permit of extended runs without the necessity of intermediate fuel and fire-cleaning stops. Aluminum has been used in the cab sheets, running boards, smoke-lifting shields, front-end platform, gage boards, sandboxes, and air-pump shields

Another 4-8-4 design built by Alco for the Union Pacific is shown in Fig. 4 and item 1, Table 1. These locomotives are essentially duplicates of those furnished in 1939 for the Union Pacific and are indicative of a successful design that warrants repetitive building.

The Milwaukee 4-8-4 shown in Fig. 5 and item 5, Table 1, is another example of recent construction in the popular 4-8-4 wheel arrangement prevalent in American railroading.

TABLE 1 STEAM LOCOMOTIVES FOR SERVICE IN U.S.A. AND CANADA

					Cylinders							Heating Surfaces					Tender Data			
Item	Builder	Owner	Wheel arrangement	Service	No.	Diam	Stroke	Boiler pressure	Driver diam	Weight on drivers	Total weight locomotive in running order	Evaporative	Superheater	Total	Grate area	Track gage	Wheels	Fuel	Water	2/3 loaded
1	MLW	Can. Pac.	2-8-2	F	2	22	32	275	63	246400	337000	3437	970	4407	70.3	56 1/2	8	18	12000	155450
2	MLW	Can. Nat.	4-8-2	P	2	24	30	260	73	236950	355700	3584	1570	5154	70.2	56 1/2	12	18	14040	226850
3	ALCO	N.Y.C.	4-8-4	F-P	2	25	32	275	75	275000	471000	4632	1977	6609	100.1	56 1/2	14	46	18000	337400
4	ALCO	Un. Pac.	4-8-4	F-P	2	25	32	300	80	270300	490700	4294	1400	5694	100.2	56 1/2	14	25	23500	329600
5	ALCO	Milwaukee	4-8-4	F-P	2	26	32	250	74	259300	460000	4477	1438	5915	96.2	56 1/2	12	25	20000	291200
6	PRR	P.R.R.	4-4-6-4	F	2 2	19 3/4 23 3/4	28 29	300	69	393000	619100	....	....	9655	121.7	56 1/2	16	40	19020	350700
7	ALCO	North Pac.	4-6-6-4	F	4	23	32	260	70	444000	644000	5749	2105	7854	152.3	56 1/2	14	27	25000	349800
8	BLW-WEST	P.R.R.	6-8-6	F-P	(Turbine-Drive)			310	68	260000	580000	5002	2050	7052	120	56 1/2	16	37 1/2	18000	347000

NOTES:
F = freight S = switching P = passenger.
Weights expressed in pounds.
Fuel in tons (2000 lb). Water in U. S. gallons.
Heating surfaces and grate areas expressed in square feet.
Boiler pressure expressed in pounds per square inch.

Wheel diameters, gage, cylinder dimensions expressed in inches.
ALCO—American Locomotive Company.
MLW—Montreal Locomotive Works.
P.R.R.—Pennsylvania Railroad.
BLW-WEST—Baldwin Locomotive Works-Westinghouse Electric Corporation.

TABLE 2 STEAM LOCOMOTIVES, FOREIGN-BUILT AND FOR FOREIGN SERVICE

					Cylinders							Heating Surfaces						Tender Data			
Item	Nationality of builders	Owner	Wheel arrangement	Service	No.	Diam	Stroke	Boiler pressure	Driver diam	Weight on drivers	Total weight locomotive in running order	Evaporative	Superheater	Total	Grate area	Track gage	Wheels	Fuel	Water	Weight 2/3 loaded	Notes
1	British	....	2-8-0	F	2	21 5/8	28	225	49 1/2	165680	189180	2213	660	2873	44	56 1/2	8	11 1/4	6602	110810	
2	British	B.B.& C.I.	2-8-2	F	2	19	24	180	48	102248	135520	1388	298	1686	32.3	Meter	8	400 Cf	4020	..	Wood fuel
3	American	French Govt.	2-8-2	F-P	2	23 1/2	28	220	65	176400	250000	2699	704	3403	55.5	56 1/2	8	12	8000	129790	
4	American (ALCO)	Cons. Rys. Cuba	2-8-2	F-P	2	22	28	190	51	179000	227000	2249	565	2814	54.8	56 1/2	8	2700 G	8000	122700	Oil-burning
5	American (ALCO)	Portuguese Rys.	2-8-2	F-P	2	21	28	200	60	141000	195500	2138	630	2768	47	66	8	3150 G	5760	100000	Oil-burning
6	American (BLW)	Brazil	2-8-2	F	2	19	20	220	42	110000	137000	1560	374	1934	30.2	Meter	8	3.3 Cords	3700	79500	Wood-burning
7	American (ALCO)	Russia	2-10-0	F	2	25	28	180	52	192500	218500	2467	685	3152	64.7	60	8	14.3	7400	119150	
8	British	South African	4-8-2	F-P	2	24	28	210	60	163520	249000	3395	665	4060	62.5	42	8	15.6	7260	123380	
9	American (BLW)	Colombia	4-8-2	F	2	18 1/2	22	210	42	119500	179300	2477	685	3162	48	36	8	1500 G	4000	69250	Oil-burning
10	American (ALCO)	Brazil	4-8-2	F	2	20	22	185	48	105500	161000	1994	500	2494	40.2	Meter	8	636 Cf	3700	..	Wood fuel
11	Australian	South Aus. Ry.	4-8-4	F-P	2	20 1/2	28	215	66	140000	249312	2454	651	3105	45	63	12	7.84	11160	159780	
12	Soviet Union	State Rys.	4-14-4	F	2	29 1/8	31-7/8	242	63	278000	434300	4822	1851	6673	129	60	12	26.3	13830	192000	

NOTES:
F = Freight P = Passenger
Fuel in tons (2000 lb).
Water in U. S. gallons.
G = gallons
C = cords
Cf = cubic feet
Weights expressed in pounds.
Fuel in tons (2000 lb).

Heating surfaces and grate areas expressed in square feet.
Boiler pressure expressed in pounds per square inch.
Wheel diameters, gage, cylinder dimensions expressed in inches.

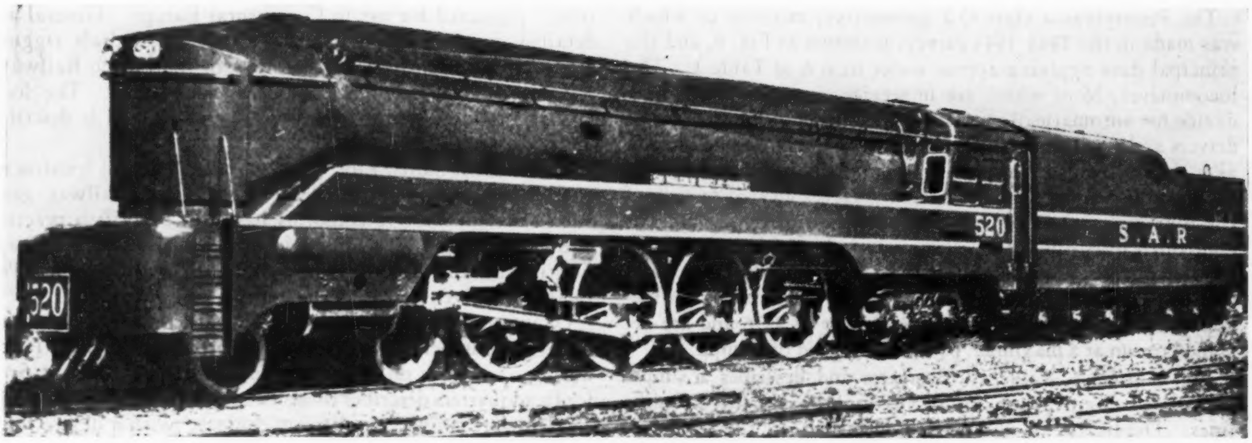

FIG. 8 4-8-4 BUILT IN THE SOUTH AUSTRALIAN RAILWAY SHOPS

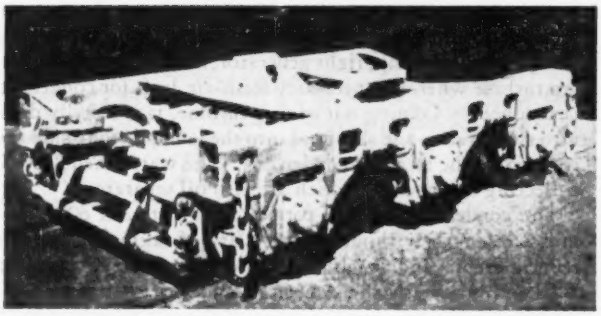

FIG. 9 ALL-WELDED TRUCK FOR THE SOUTH AUSTRALIAN 4-8-4

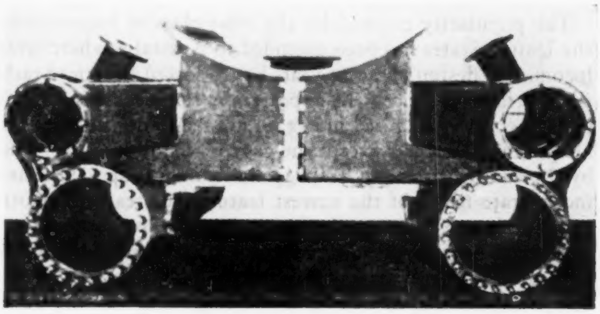

FIG. 10 ALL-WELDED CYLINDER-SADDLE ASSEMBLY FOR THE SOUTH AUSTRALIAN LOCOMOTIVE

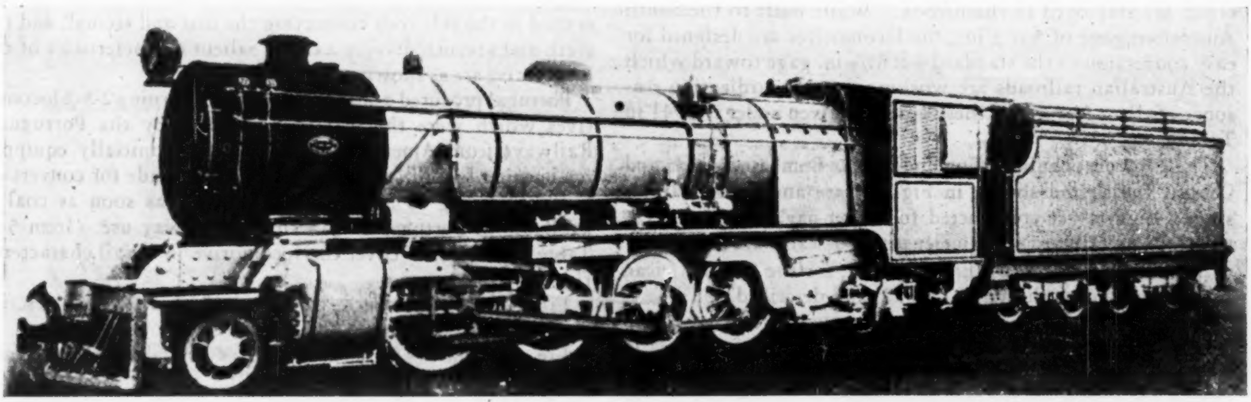

FIG. 11 METER-GAGE 2-8-2 FOR INDIA

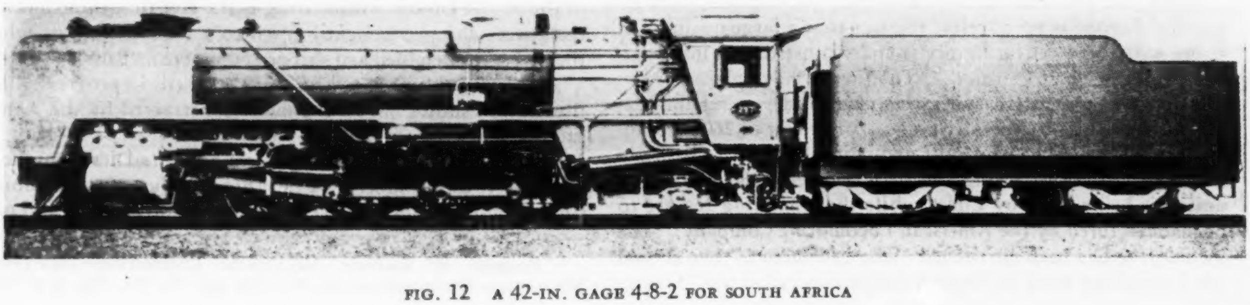

FIG. 12 A 42-IN. GAGE 4-8-2 FOR SOUTH AFRICA

The Pennsylvania class Q-2 locomotive, mention of which was made in the 1943–1944 survey, is shown in Fig. 6, and the principal data applying appear under item 6 of Table 1. The locomotives, 26 of which are in service, are equipped with a device for automatically arresting the slipping of either set of drivers and restoring the power to the slipping engine as soon as it slows down to the speed of the nonslipping engine. This is accomplished by means of butterfly valves located in each of the four main steam pipes. The operation of these valves is controlled by a differential electric switch which is driven by small wheels running on the treads of one of the No. 2 and one of the No. 3 driving wheels. These locomotives are designed for a nominal cylinder horsepower of 7976 and are designed to run at a maximum permissible speed of 80 mph.

Fig. 7 (item 7, Table 1) illustrates and describes a simple articulated engine built for service on the Northern Pacific lines. Duplicates of these were furnished to the Spokane, Portland and Seattle.

FOREIGN STEAM LOCOMOTIVES

The popularity enjoyed by the 4-8-4 class of locomotive in the United States has been extended to Australia where steam-locomotive design in recent years has followed American rather than British practice. In appearance, the streamlined units, one of which is pictured in Fig. 8, are American in practically all principal features except the gage which is 5 ft 3 in. Built by the South Australian Railways in its own shops, these units incorporate many of the newest features in steam-locomotive construction. These are the first Australian locomotives to be equipped throughout with roller journal bearings. Welded fabricated construction has been used in many of the important components. The tender truck frames, Fig. 9, the tender underframe and body, and the cylinder assembly, Fig. 10, are of welded construction. Unusual is the all-welded construction employed in the firebox. The tube sheet, door sheet, and syphon joints are all electrically welded butt joints and no rivets are employed in the firebox. While built to the South Australian gage of 5 ft 3 in., the locomotives are designed for easy conversion to the standard 4-ft $8^1/_2$-in. gage toward which the Australian railroads are working for standardization reasons. Salient features of these units are given under item 11 in Table 2.

The 2-8-2 units built in England for the Bombay, Baroda and Central India, and shown in Fig. 11, are among the largest simple engines yet constructed for meter-gage working. Dimensional details are given under item 2 of Table 2.

A 4-8-2 class of engine, English-built, for the South African 42-in-gage lines is shown in Fig. 12, and described in Table 2, under item 8. These are the first locomotives delivered to South Africa from England since the outbreak of the war in 1939. The boiler is the largest yet fitted to a 42-in-gage simple engine and represents the maximum that can be used within the restrictions imposed by wheel arrangement, clearance limitations, and axle loading.

While the presence of American-built locomotives in Continental Europe is no novelty, the fact that a large quantity of steam motive power for France is under construction in American plants is worthy of note. The French have placed orders for some 700 locomotives with American builders in rehabilitating the war-torn railways of France. The first of 260 locomotives, a 2-8-2 design, was built and shipped from the Baldwin Locomotive Works during the past summer; 180 of the 700 units are being built by Lima, while the remaining 260 are to be manufactured by the American Locomotive Company. The locomotive has been christened "The Liberation," but should not be confused with an English design also called the "Liberation," projected for use in Continental Europe. General and detailed construction, with the exception of draft rigging, bumpers, headlighting, etc., peculiar to the French Railways, follows American standard practice and design. The locomotive (Baldwin-built) is shown in Fig. 13 and is described under item 3 in Table 2.

The English-built "Liberation" is a 2-8-0 design constructed to the limitations of the Berne international railway gage. While the locomotive conforms basically to British practice, every effort has been made to incorporate the best features of Continental and American as well as of British design. Particulars are given in Fig. 14 and under item 1 of Table 2.

Of interest is the German-built 2-10-0 condenser-type locomotive, a number of which were captured by the Allied Forces during operations on the Continent. Military Railway Service Headquarters describes these locomotives as follows:

"They are conventional steam engines,[2] with a device to reclaim the exhaust steam in the tender. The exhaust steam coming from two cylinders is joined and flows to a suction-fan turbine in the smokebox. From there it is driven through a large exhaust pipe on the left side of the engine through an oil separator to the tender. All exhaust steam from the cylinders, feed pumps, air pump, light generator, and safety valve, enters a fan turbine where the necessary fresh-air draft for condensation is produced. Coming out of this turbine, it is equally divided into two streams and admitted into the left and right side radiators where the steam is condensed. The water then flows into collecting chambers in which are also oil separators."

The condensing feature permits runs between 600 and 700 miles in length without the necessity of taking on water and reduces firebox and flue difficulties to a minimum, it is reported.

In contrast with the American and British practice of arranging a relatively large number of driving axles in two separate rigid wheel bases, the 4-14-4 locomotive built in Russia has an unusually large number of drivers in a rigid wheel base. This locomotive, the largest yet built in the Soviet, is shown in Fig. 15. The diagram indicates that a laterally flexible joint is used in the side rods connecting the first and second, and the sixth and seventh driving axles. Salient characteristics of the locomotive are as shown in item 12, Table 2.

Portugal procured a shipment of 22 oil-burning 2-8-2 locomotives which were the first to be secured by the Portuguese Railways from American builders. While initially equipped for burning fuel oil, provisions have been made for conversion to coal-burning as a permanent measure, as soon as coal is available in Portugal in quantity for railway use. Item 5 of Table 2 and Fig. 16 cover the locomotive in detail characteristics and appearance.

Figs. 17, 18, 19, and items 6, 9, and 10 of Table 2 describe three designs built for narrow-gage lines in South America.

Fig. 20, item 4 of Table 2, illustrates a standard-gage Mikado design, ten of which were furnished for the Consolidated Railroads of Cuba by Alco.

Fig. 21, item 7 of Table 2, illustrates a 5-ft-gage design built in large quantities by several American builders for the railroads of the Soviet Union. Interesting is the fact that these locomotives were shipped knocked-down to a west-coast port where they were reassembled and shipped complete on Russian ships to Vladivostock while the Pacific war was still in progress. The illustration shows one of the many constructed by the American Locomotive Company.

Efforts are still being made to connect the Diesel engine in direct drive to locomotive axles. Fig. 22 illustrates a combination steam-Diesel locomotive built by the Voroshilovgrad Loco-

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[2] "Progress in Railway Mechanical Engineering—1943–1944," MECHANICAL ENGINEERING, vol. 66, 1944, pp. 783–798; Fig. 9, p. 789.

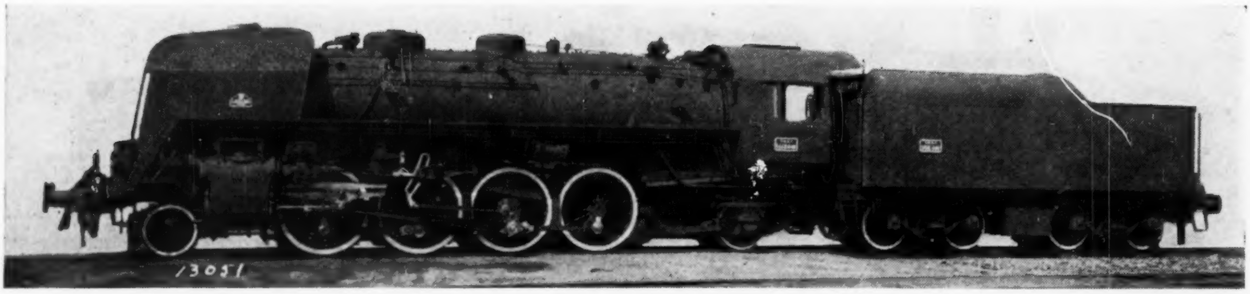


FIG. 13 2-8-2 FOR THE RAILWAYS OF FRANCE, 700 OF WHICH ARE BEING BUILT BY AMERICAN BUILDERS

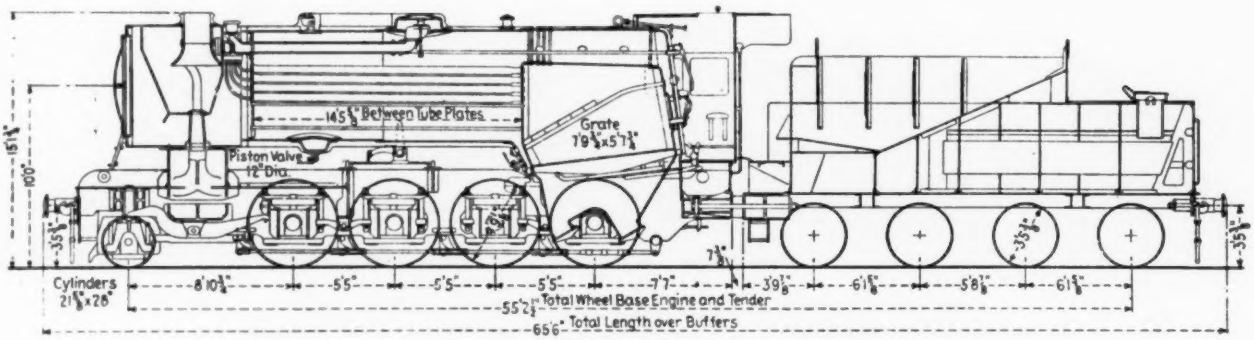


FIG. 14 STANDARDIZED DESIGN PROJECTED FOR GENERAL USE IN CONTINENTAL EUROPE

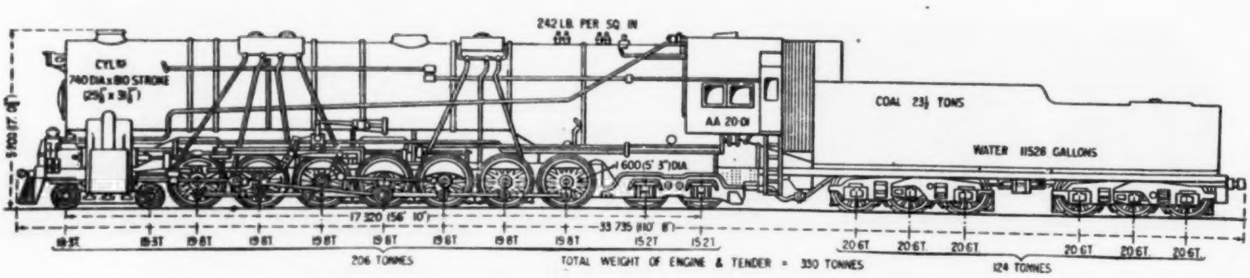


FIG. 15 SOVIET-BUILT 4-14-4 WITH AN UNUSUALLY LARGE NUMBER OF COUPLED AXLES IN A RIGID FRAME

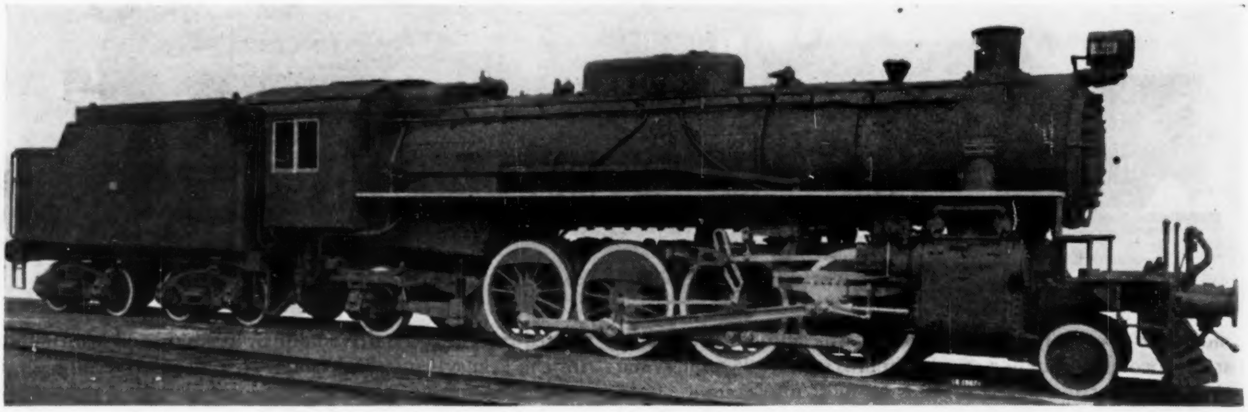


FIG. 16 2-8-2 REPRESENTATIVE OF THE FIRST AMERICAN-BUILT STEAM LOCOMOTIVES FOR PORTUGAL

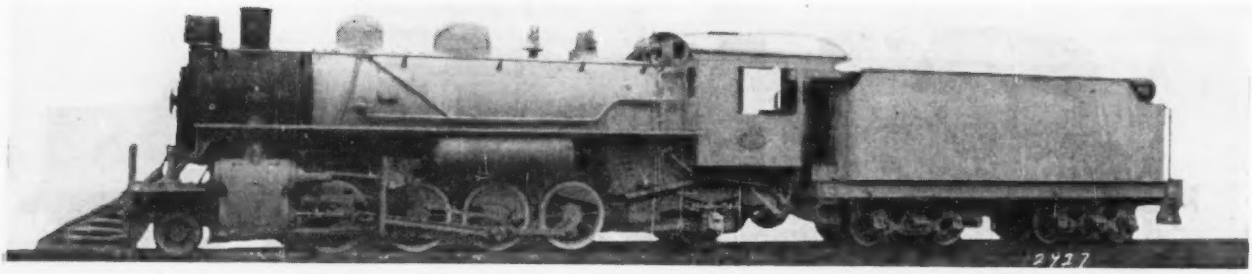


FIG. 17 2-8-2 WOOD BURNER FOR THE LEOPOLDINA; BRAZIL

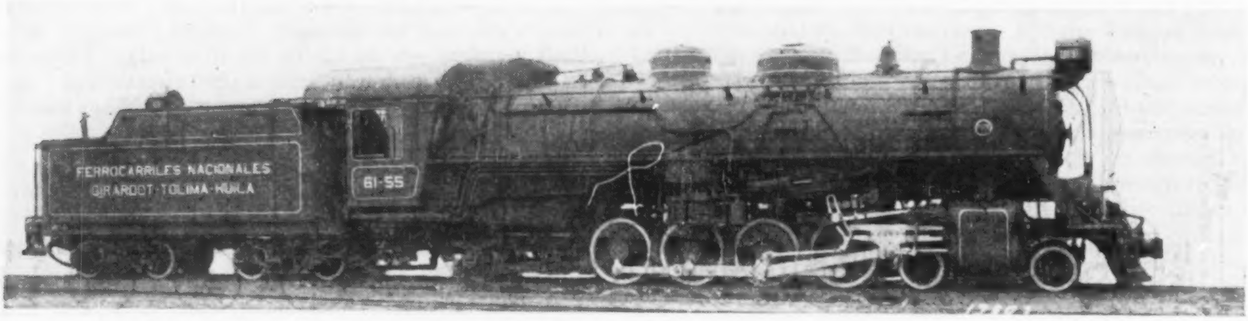


FIG. 18 A 38-IN-GAGE 4-8-2 FOR COLOMBIA

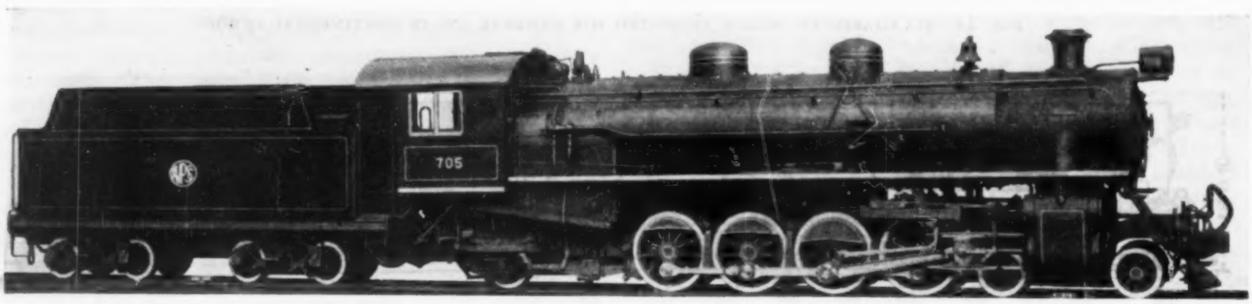


FIG. 19 METER-GAGE 4-8-2 FOR PARANA-SANTA CATARINA; BRAZIL

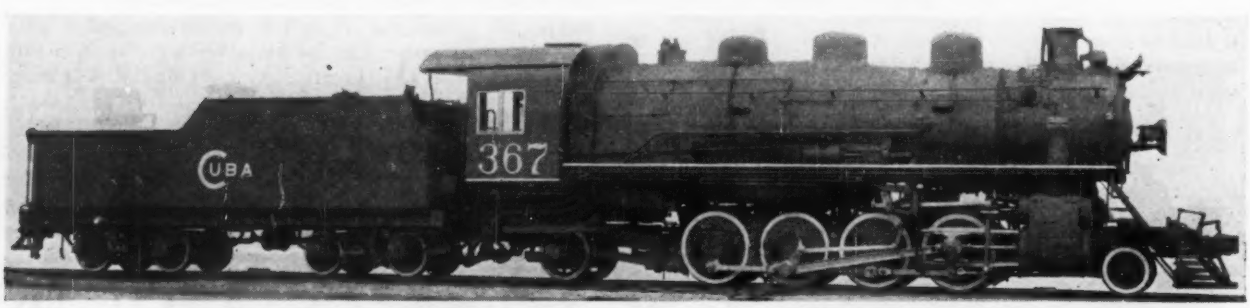


FIG. 20 ONE OF TEN MIKADOS FOR CONSOLIDATED RAILROADS OF CUBA

motive Works in the Soviet Union. The unit functions as a steam locomotive up to a speed of approximately 25 mph, when the Diesel portion of the drive is brought into action. Both engines operate to furnish power at speeds above the Diesel feature cut-in speed.

STEAM-TURBINE LOCOMOTIVES

Interest in the application of the steam turbine to rail motive power was high-lighted by the appearance late in 1944 of the geared-turbine locomotive built by Baldwin and Westinghouse for the Pennsylvania Railroad. This locomotive, Fig. 23, is a noncondensing machine and is equipped with a conventional type of fire-tube boiler of sufficient capacity in steam flow to permit a rating of 6550 rail hp at 70 mph. Two turbines have been fitted, the main turbine for forward motion running at 9000 rpm at a locomotive speed of 100 mph, and a reduced-capacity turbine, developing approximately 1500 hp at a turbine speed of 8300 rpm, corresponding to a locomotive speed of 22 mph for

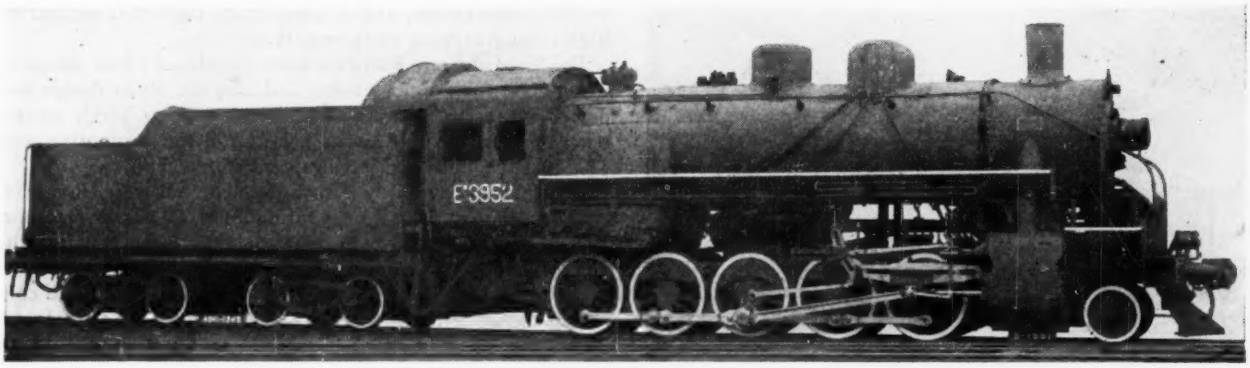


FIG. 21 A 5-FT-GAGE 2-10-0 FOR THE SOVIETS

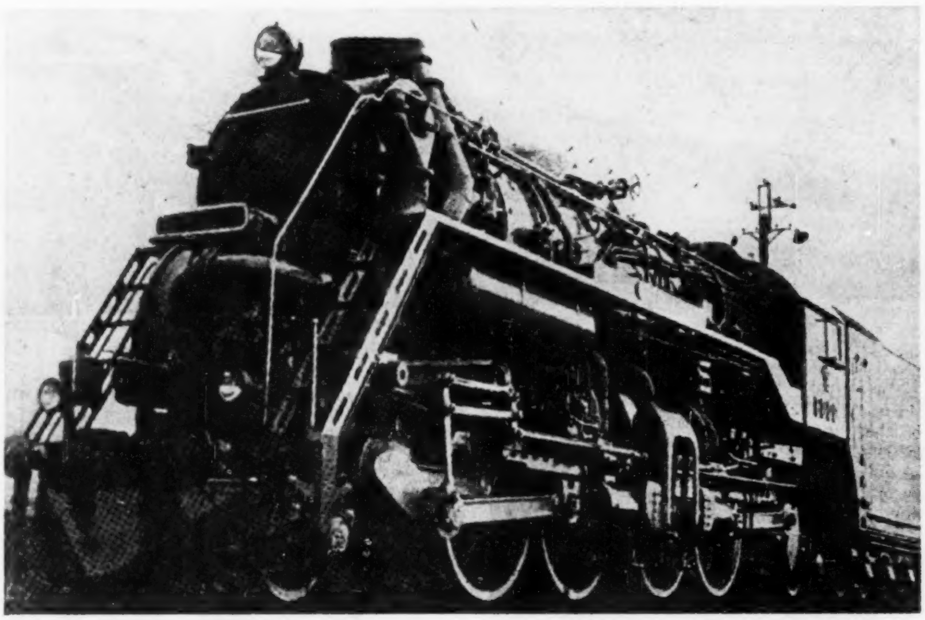


FIG. 22 EXPERIMENTAL COMBINED STEAM-DIESEL, DIRECT-DRIVE 2-8-2 BUILT IN THE SOVIET UNION

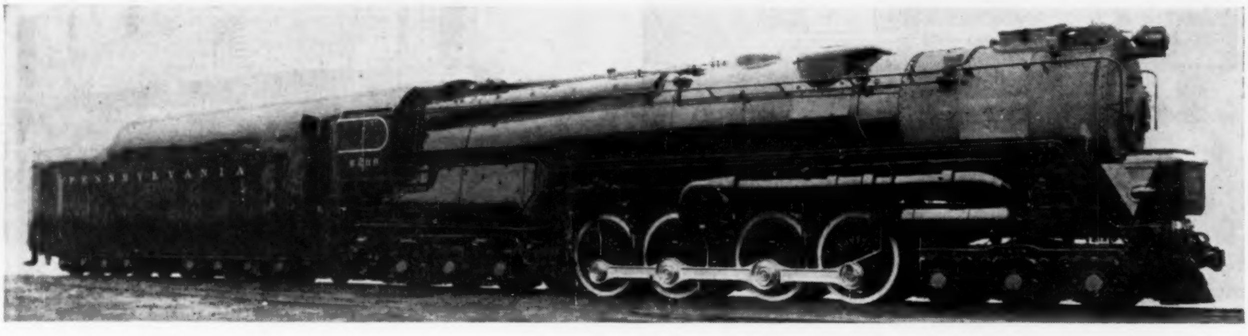


FIG. 23 FIRST DIRECT-DRIVE STEAM-TURBINE LOCOMOTIVE BUILT IN THE UNITED STATES, FOR THE PENNSYLVANIA RAILROAD

reverse operation. Both turbines are geared to the center pair of driving wheels, and a clutch brings the reverse turbine into action for reverse locomotive operation. A steam rate of 14.6 lb per drawbar hp-hr has been observed at speeds between 70 and 75 mph.

Principal dimensional data describing the locomotive appear under item 8 of Table 1.

A detailed description of the locomotive with performance curves and characteristics has been given by Newton and Brecht.[8]

ELECTRIC LOCOMOTIVES

A new electric locomotive, Fig. 24, of notable construction

[8] "A Geared Steam-Turbine Locomotive," by J. S. Newton and W. A. Brecht, *Railway Age*, vol. 118, Feb. 17, 1945, pp. 337–340, and 349.

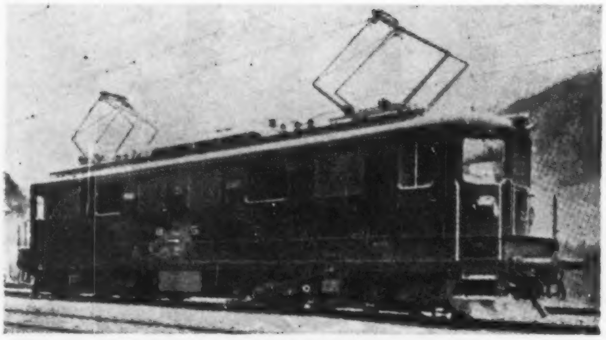


FIG. 24 A 15,000-V B-B 4000-HP, 1-HR RATING, ELECTRIC FOR THE SWISS FEDERAL RAILWAYS

welded construction, and motor-voltage control is secured by high-tension tapping on the transformer.

The Swedish State Railways have introduced a new design of locomotive for freight service, and like the Swiss design just described, places all weight on drivers in two 3-axle swivel trucks. With a total weight of 112 tons, the locomotive rates 3600 hp (one hour) and has a top speed of 50 mph.

Continuing the tendency toward placing all weight on drivers, the two 360-ton 5000-hp (continuous at rail) 11,000-v motor-generator-type locomotives, now under construction for the Great Northern Railway, will have a B-D + D-B wheel arrangement. The locomotives will be built in single-cab construction and will, when completed, be the largest single-cab electric locomotives constructed. Knuckle-to-knuckle length will be approximately 100 ft.

The first locomotive of any type to carry 1,000,000 lb on

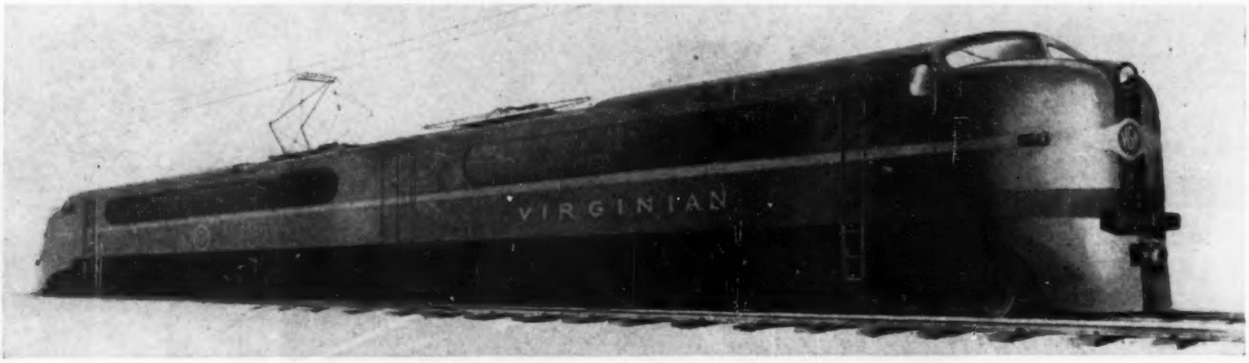


FIG. 25 ARTIST'S CONCEPTION OF THE 11,000-V 500-TON MOTOR GENERATOR ELECTRIC LOCOMOTIVES FOR THE VIRGINIAN

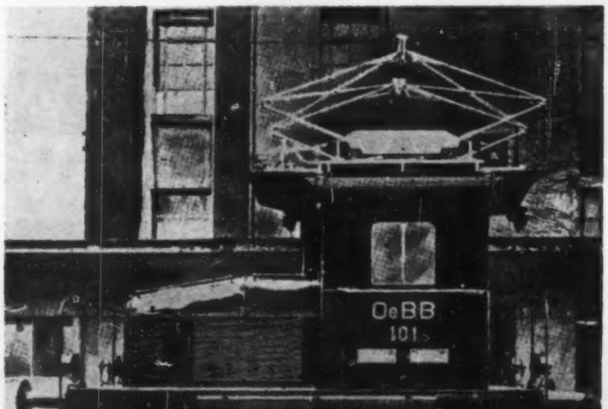


FIG. 26 A SMALL 15,000-V ELECTRIC SWITCHER FOR THE OENSINGEN-BALSTHAL RAILWAY, SWITZERLAND

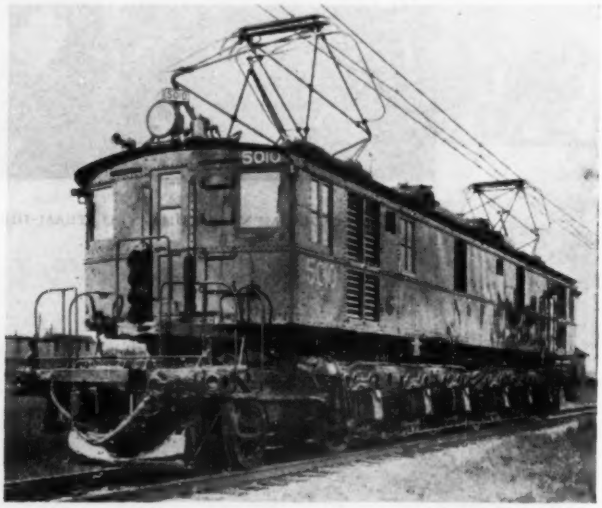


FIG. 27 1-C + C-1 11,000-V ELECTRIC LOCOMOTIVE AS ORIGINALLY CONSTRUCTED

has been placed in service on the Swiss Federal Railways. The locomotive, an 88-ton machine with all weight on drivers in a B-B wheel arrangement, is rated at 4000 hp (one-hour rating) and is designed for a maximum speed of 80 mph. Each of the four traction motors drives its axle through a Brown-Boveri spring-steel-disk flexible drive and spur gearing. The large horsepower rating and the absence of guiding wheels are both departures from heretofore normal practice. Trucks are of

drivers was ordered by the Virginian Railway for use in its heavy coal-haulage operations over the Allegheny Mountains. These motor-generator electric locomotives are to work on an 11,000-v, 25-cycle single-phase power supply and will be constructed as two-cab units with all weight on a total of sixteen driving axles, and a continuous rail horsepower rating of 6800 hp, Fig. 25.

A small single-motored electric switching locomotive of

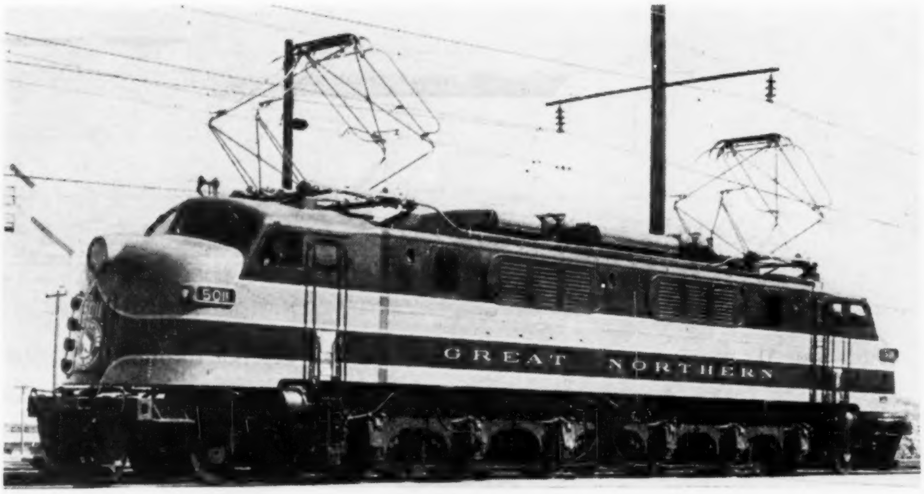


FIG. 28 THE LOCOMOTIVE SHOWN IN FIG. 27, AS STREAMLINED WITH A NEW CAB STRUCTURE

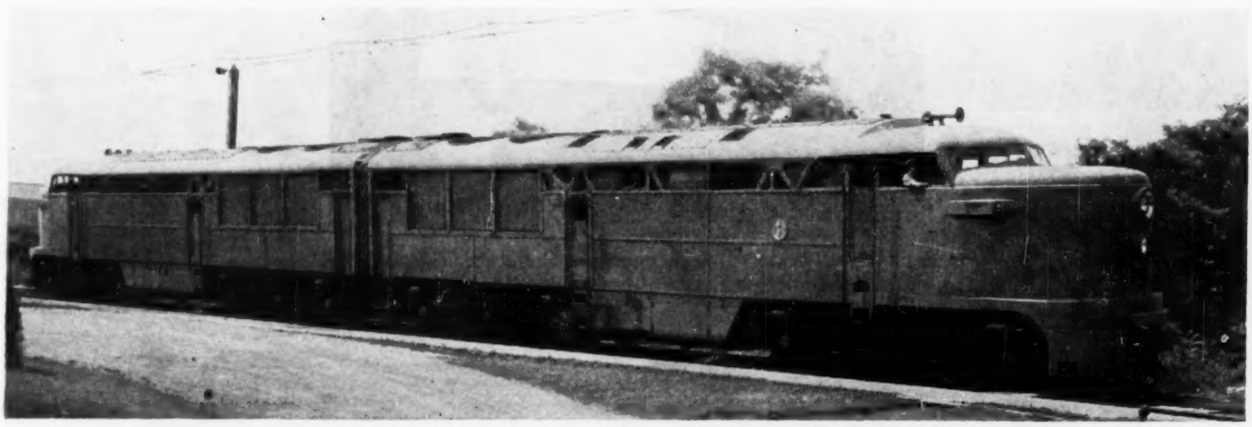


FIG. 29 TWO A-UNITS OF THE FAIRBANKS-MORSE ROAD DIESEL-ELECTRIC IN TEST ON GENERAL ELECTRIC TEST TRACK

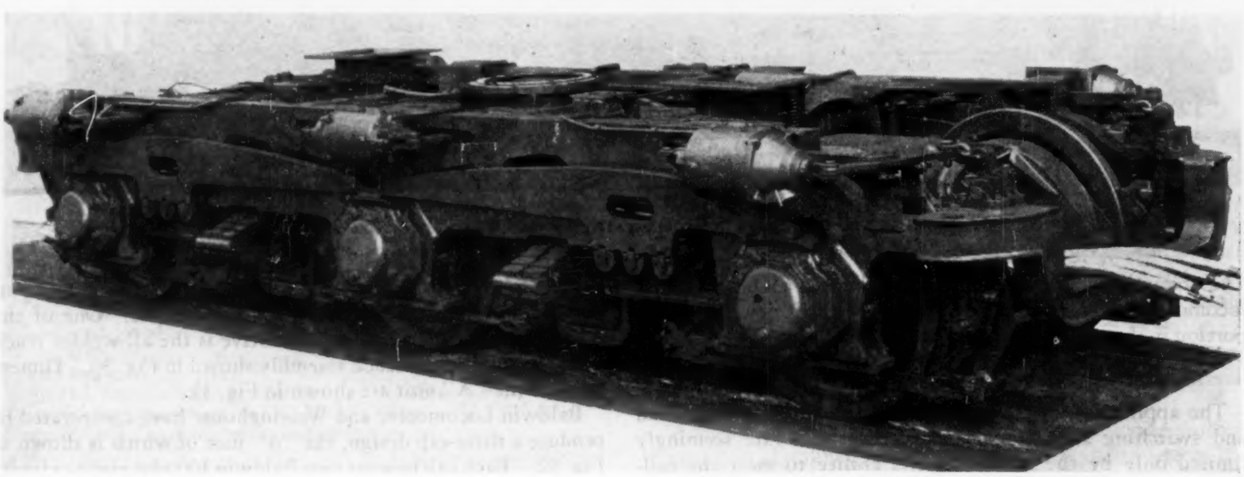


FIG. 30 ALL-WELDED FABRICATED TRUCK FOR FAIRBANKS-MORSE DIESEL-ELECTRIC

Swiss construction with a B-wheel arrangement and side-rod drive between the two axles is shown in Fig. 26. The single motor is geared to one of the two driving axles.

An interesting conversion project performed on an electric locomotive in the owner's shops is depicted in Figs. 27 and 28. The former of the two figures illustrates the locomotive, a Great Northern 1-C + C-1 motor-generator type, as originally built in 1927, and Fig. 28 shows the rebuilt streamlined product.

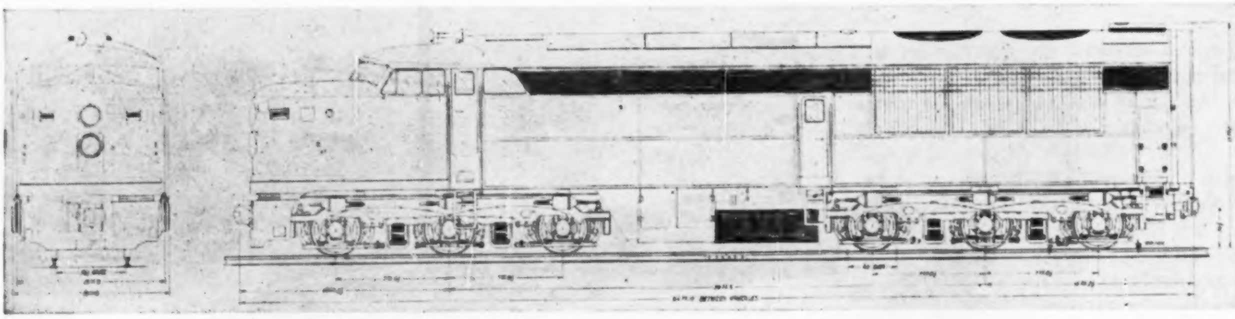


FIG. 31 OUTLINE OF A-UNIT FAIRBANKS-MORSE DIESEL-ELECTRIC LOCOMOTIVE

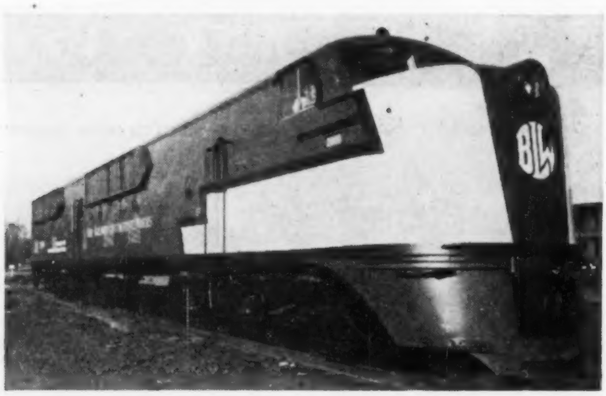


FIG. 32 BALDWIN-WESTINGHOUSE A-UNIT DIESEL-ELECTRIC ROAD LOCOMOTIVE

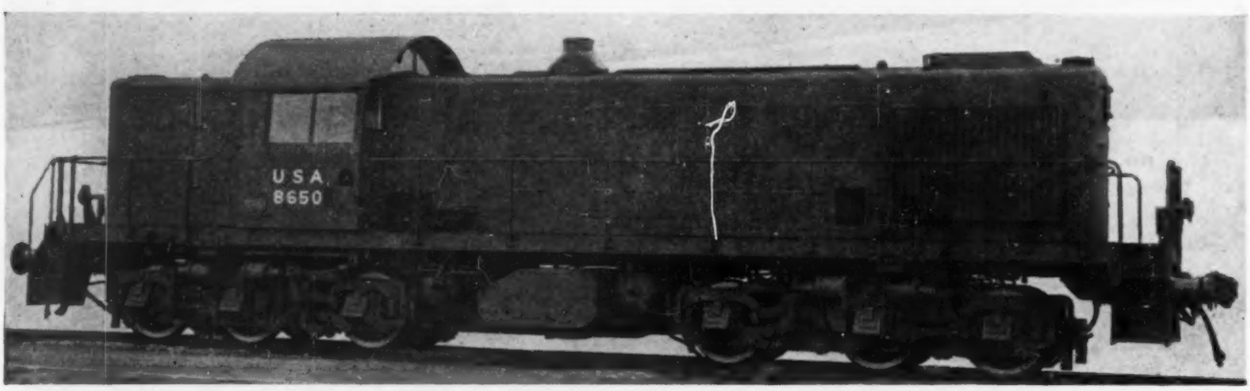


FIG. 33 ALCO-G.E. CO. DIESEL-ELECTRIC SIX-AXLE 1000-HP ROAD LOCOMOTIVE FOR U. S. ARMY

The streamlined noses were purchased from a Diesel-electric locomotive builder and were "grafted" on to a new cab center portion in the railway's car shops at St. Paul.

DIESEL-ELECTRIC LOCOMOTIVES

The application of Diesel-electric locomotives in both road and switching services continues apace at a rate seemingly limited only by the manufacturer's ability to meet the railroads' demands for this type of power.

Two new 6000-hp multicab designs have made their appearance during the past year.

The three-cab locomotive placed on the market by Fairbanks-Morse & Company is in test at the Erie Works of the General Electric Company at this writing, Fig. 29. Each cab houses a 10-cylinder $8^1/_8$-in. × 10-in. two-cycle opposed-piston engine, running at 850 rpm and delivering 2100 bhp, 2000 hp of which is available for traction-generator input. One of the noteworthy features of this locomotive is the all-welded truck frame utilized in the truck assembly shown in Fig. 30. Dimensions of the "A" unit are shown in Fig. 31.

Baldwin Locomotive and Westinghouse have co-operated to produce a three-cab design, the "A" unit of which is shown in Fig. 32. Each cab mounts two Baldwin 1000-hp eight-cylinder in-line, four-cycle normally aspirated engines, with cylinders of $12^3/_4$ in. × $15^1/_2$ in. bore and stroke, and running at 625 rpm. These engines are essentially duplicates of those employed in the standard Baldwin-Westinghouse 1000-hp switching locomotives.

Comparative characteristics of the two designs, arranged as 6000-hp locomotives, are given in Table 3. Various combina-

FIG. 34 1000-HP ROAD LOCOMOTIVE FOR BRAZIL

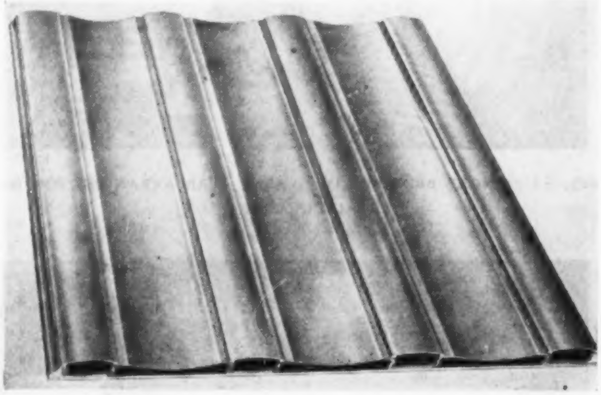


FIG. 35 DETAIL OF FLUTED STAINLESS STEEL OR ALUMINUM SIDE SHEATHING

tions of "A" and "B" units of both designs are operable as complete locomotives up to a total of 6000-hp rating.

Fig. 33 illustrates a six-axled version of the standard 1000-hp road-switching locomotive built by the American Locomotive Company for the U. S. Army for service on the Trans-Iranian Railways. Six geared traction motors are employed and all

TABLE 3 COMPARISON OF DIESEL-ELECTRIC-LOCOMOTIVE TYPES

Design	F-M & Co.	BLW-West.
Weight, in working order, lb	984000	1,140,000
on driving wheels, lb	684000	760,000
on idle wheels, lb	300000	380,000
per driving axle, lb	57000	63,333
per idle axle, lb	50000	63,333
Length, over knuckles, ft-in	194-6	240-0
wheel ban per cab, ft-in	51-10	64-4
rigid wheel base, ft-in	15-5	15-4
Wheel arrangement	3(A1A-A1A)	3(A1A-A1A)
Wheel diameter, in	40	40
Engine hp, gross	6300	....
Engine hp, net to traction generators	6000	6000
Tractive effort, maximum, lb	225000	216000
Tractive effort, continuous maximum, lb	112200	85500
Speed at cont. max. tract. effort, mph	17	21.5
Horsepower at rail corresponding to max. cont. t.e.	5100	4900
Regenerative braking effort, maximum lb	108000	....
Maximum permissible speed, mph	75	90
Gearing, traction motors	68/19	21/58
Motors, number and type	12-GE-746	12-W-370
Number of cabs	3	3

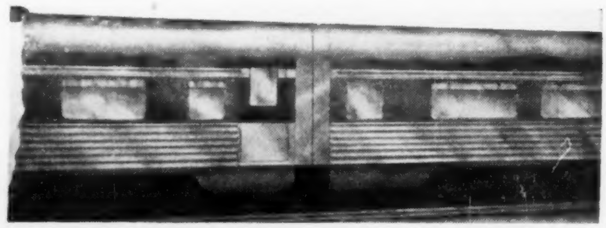


FIG. 36 ARTIST'S CONCEPTION OF CAR SIDES WITH FLUTED STAINLESS STEEL OR ALUMINUM SHEATHING

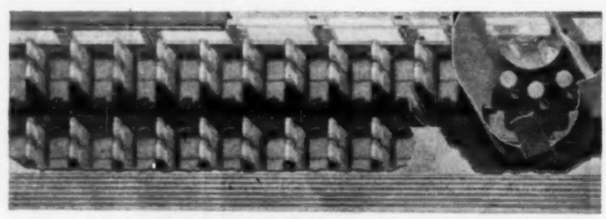


FIG. 37 ISOMETRIC CUTAWAY OF "SLUMBERLINER" SHOWING SEATING AND WOMEN'S COMPARTMENT

weight is carried on driving wheels. Wheel-loading restrictions in force on the Iranian lines prevented the use of the standard four-motored four-axle locomotive. The standard 1000-hp unit, as furnished for the Central of Brazil to a gage of 63 in., is shown in Fig. 34.

CAR CONSTRUCTION AND DEVELOPMENTS

In a determined effort to retain much of the patronage thrust upon them by curtailment of private passenger motorcar operation, a condition born of gasoline and tire rationing and lack of new motorcars, many of the railroads have announced the placing of orders for new passenger-car equipment to be run in new trains in attractive services which they hope will appeal to the riding public. Orders for some 1200 passenger-train cars are now on the books of carbuilders.

American Car and Foundry is offering construction utilizing framing in aluminum alloys, copper-bearing open-hearth steel or low-alloy high-tensile steels, with cross-bearers, center sills, and end sills of open-hearth carbon steel or low-alloy high-tensile steel with a variety of exterior sheathing arrangements. Stainless-steel fluted sections, unpainted, or anodized aluminum extrusions unpainted, in bright finish, Figs. 35 and 36, lend attractiveness to exteriors while minimizing the cost of finish maintenance. In some instances riveted or spot-welded

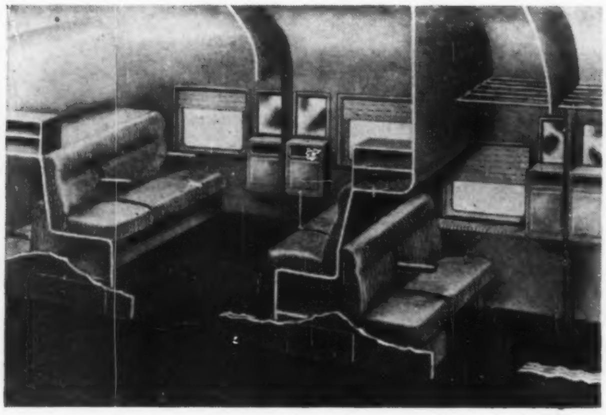


FIG. 38 CUTAWAY SHOWING "BUDGETTE" ROOMS, ARRANGED FOR DAY OCCUPANCY

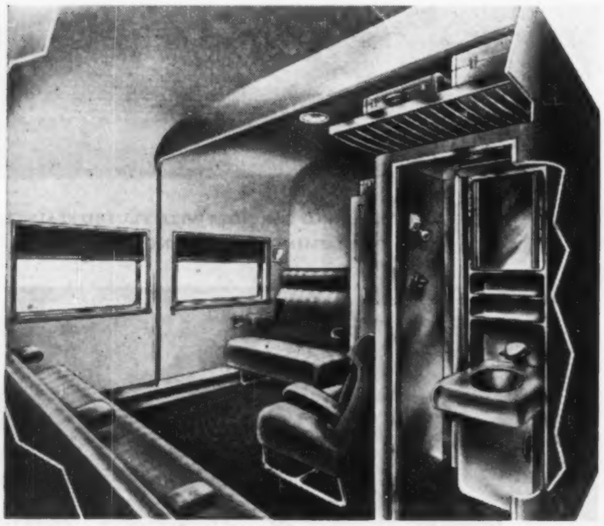


FIG. 39 MASTER ROOM IN "CABIN" CAR, SHOWING SEATING ARRANGEMENT AND PRIVATE TOILET AND BATH FACILITIES

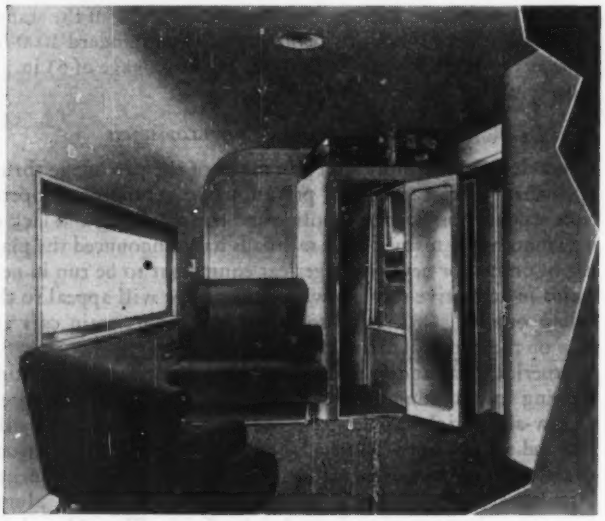


FIG. 40 DOUBLE BEDROOM IN "CABIN" CAR ARRANGED FOR DAY OCCUPANCY

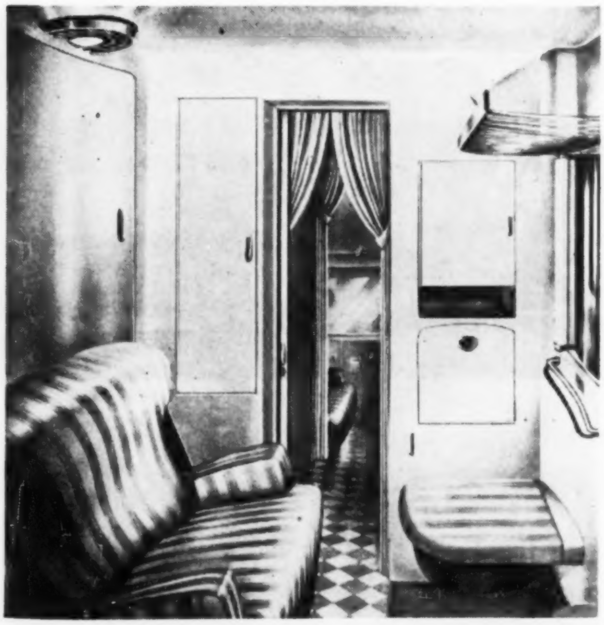


FIG. 41 SINGLE BEDROOM IN "CABIN" CAR ARRANGED FOR DAY OCCUPANCY

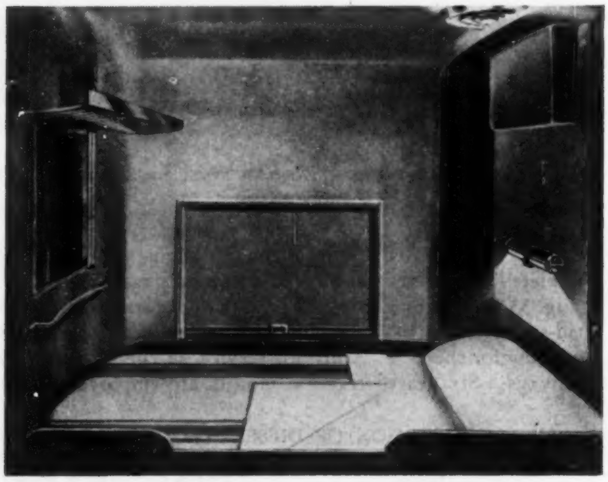


FIG. 42 SINGLE BEDROOM IN "CABIN" CAR ARRANGED FOR NIGHT OCCUPANCY

sheet-steel sheathing with exterior painting and aluminum bands above and below windows are employed.

Catering to the coach class of travel, ACF has brought out the "Slumberliner," a streamlined coach with conveniences and innovations hitherto reserved for the Pullman trade. Fig. 37 shows an isometric cut-away view of this coach with the women's compartment featuring a semicircular combination "make-up" and "wash-up" table. When the lids in the three-place table are raised, the fixture becomes a washstand. With the lids down vanity dressers with wing mirrors and toiletries dispensers are available for the passengers' use. The men's room is equipped with disappearing washbasins which, when folded back, form the back of a comfortable three- or four-seat couch. All plumbing is centralized and completely hidden from view. Sixty individual reclining-type seats are provided to complete the car's appointments.

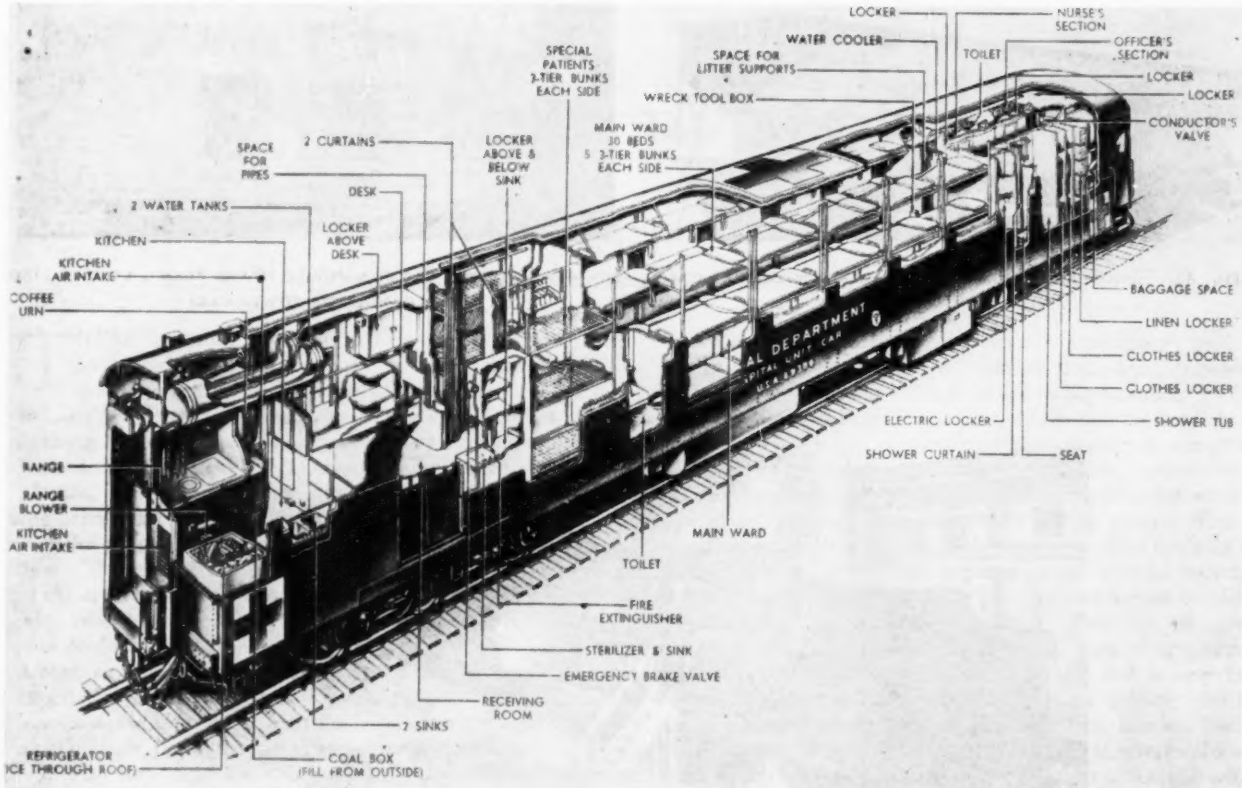


FIG. 43 HOSPITAL CAR FOR U. S. ARMY

Illustrative of the advanced designs in sleeping cars are those being built by the Edw. G. Budd Manufacturing Company, and illustrated in Figs. 38 to Fig. 42, inclusive. The first of these is an all-room car with private single-occupancy day and night accommodations for 32 passengers. To be known as the "Budgette," typifying its low-cost room service, it is intended to replace the open-section sleeper and provide more accommodations in an 85-ft car than could be furnished in a 12-section drawing room car (see Fig. 38).

FIG. 44 LARGE CAPACITY (70 TONS) TRIPLE HOPPER CAR

One of the new cars contains double- and single-bedroom accommodations, with some of the beds arranged transversely and others longitudinally of the car with a view to satisfying passenger preferences as to positions of beds. Complete toilet facilites and shower baths are included in the double bedrooms.

Adjacent double bedrooms can be converted into a large single master room by the removal of the intervening partition, Fig. 39. The double bedroom, arranged for day occupancy, is shown in Fig. 40.

An 85-ft "Cabin" car, containing 22 cabins, designed for single occupancy, is the third type offered by Budd. Fig. 41 illustrates the cabin made up for day occupancy, while Fig. 42 shows the accommodations when arranged for night travel.

The Burlington placed in service during the past summer an experimental car with a glass-enclosed observation compartment extending upward through the roof. The compartment contains 24 seats and is approximately 22 ft 6 in. long, located at the longitudinal center section of the car at such a height to bring the seated passengers' heads and shoulders well above the normal roof line, affording a view in all directions. The dome is insulated and air-conditioned. Two new trains with all of the passenger-carrying cars embodying the new "Vista-dome" construction are under construction for the Burlington Twin Cities Zephyr runs.

Fig. 43 shows a perspective cut-away view of a hospital-unit

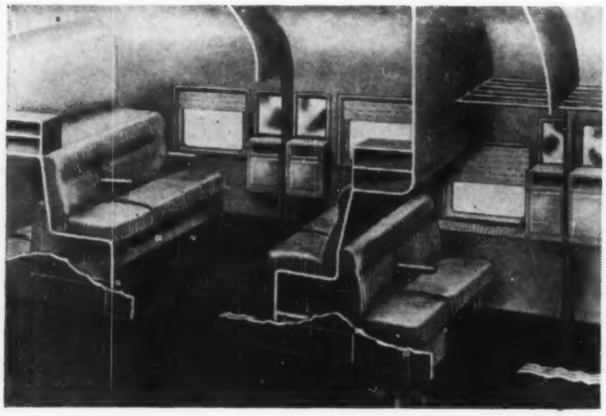
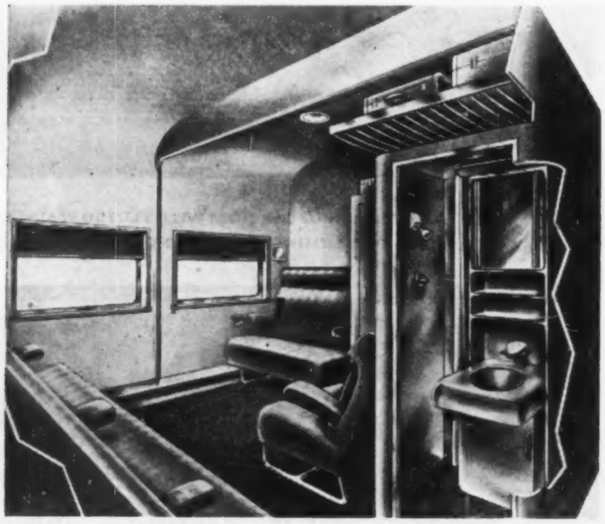


FIG. 38 CUTAWAY SHOWING "BUDGETTE" ROOMS, ARRANGED FOR DAY OCCUPANCY



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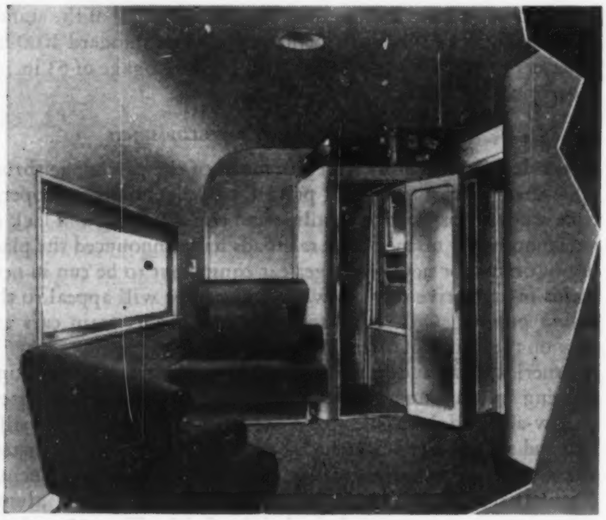

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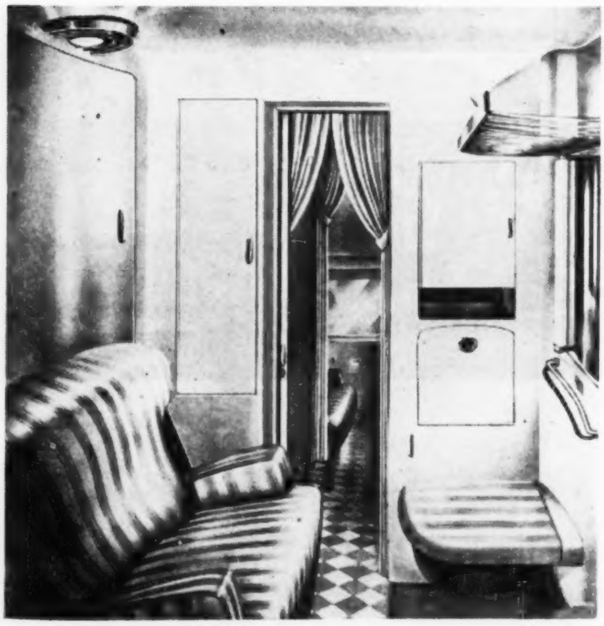
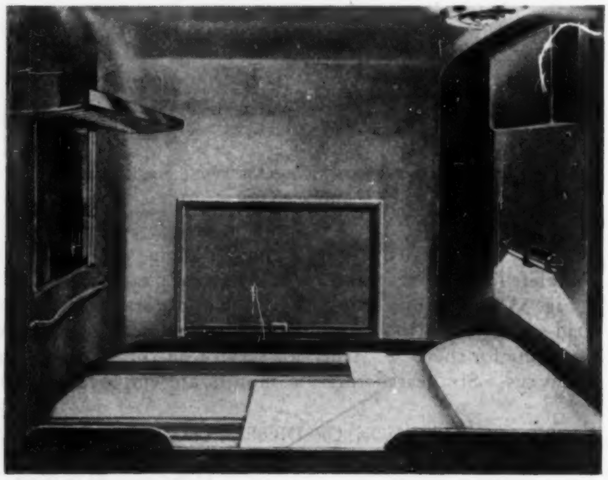


FIG. 41 SINGLE BEDROOM IN "CABIN" CAR ARRANGED FOR DAY OCCUPANCY



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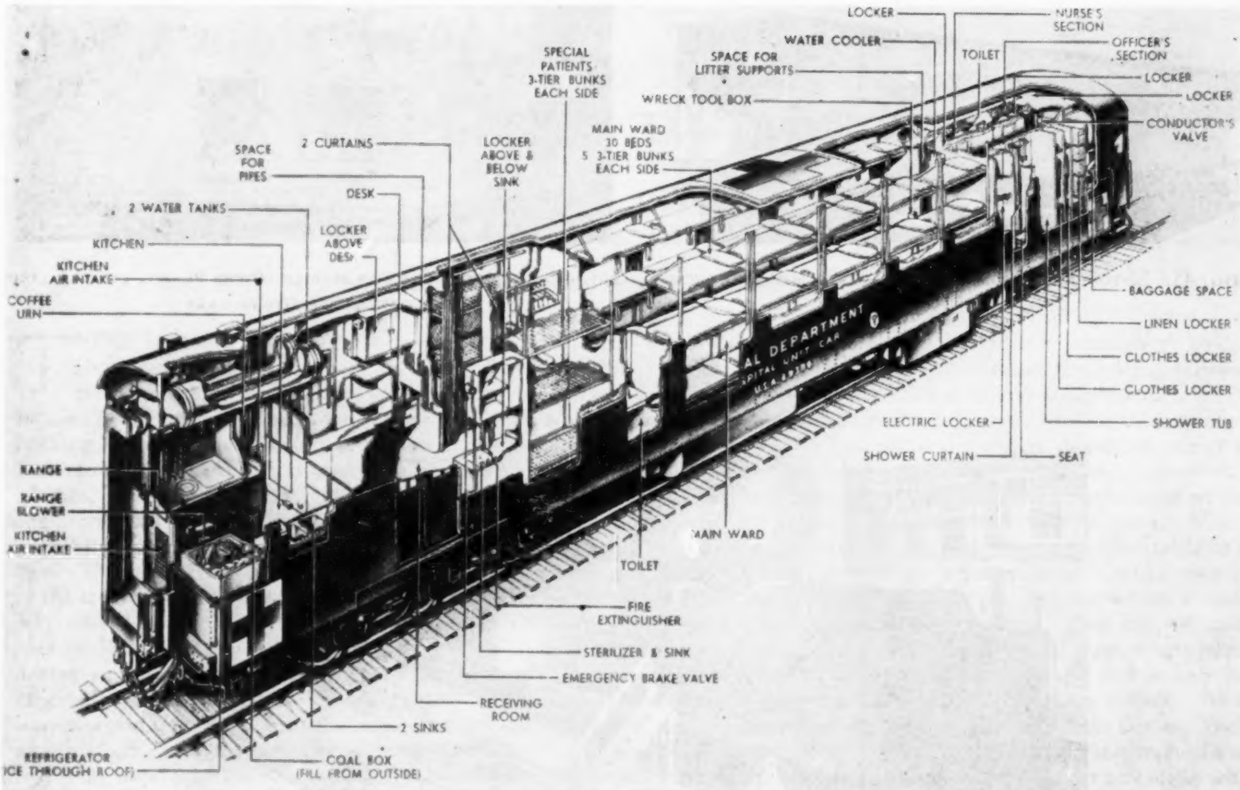

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Fig. 43 shows a perspective cut-away view of a hospital-unit

FIG. 45 70-TON ALUMINUM HOPPER CAR FOR MISSOURI PACIFIC

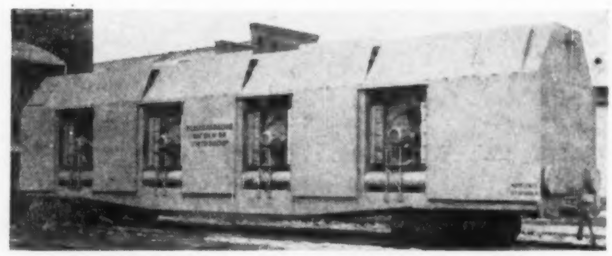

FIG. 47 RADIATOR CAR FOR MOBILE POWER PLANT, USED IN LIEU OF CONDENSER TOWER CARS

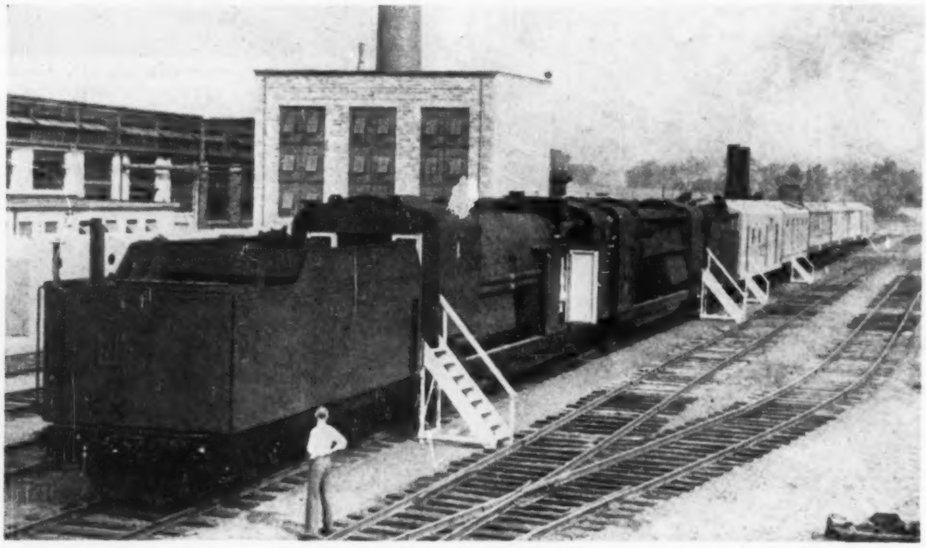

FIG. 46 TEN-CAR MOBILE POWER PLANT FOR SOVIET UNION

car built for the U. S. Army. The car is complete with kitchen, receiving room, nurse's and officer's quarters, a main ward with 30 beds in five 3-tier bunks on each side of the car, and a special patients' ward accommodating six patients.

Less spectacular but nonetheless noteworthy are the large-capacity triple-hopper car, Fig. 44, and the aluminum open hopper shown in Fig. 45. Each car has a capacity of 140,000 lb. The lightweight of the steel car is 55,500 lb, while that of the aluminum car is but 37,000, a weight indicative of the saving in dead weight made possible by the use of lightweight alloys.

MOBILE POWER PLANTS

Last year's report described the 10,000-kw mobile plants built for the Navy for domestic use. The past year has seen the construction and export of a large number of mobile rail-mounted steam power plants for use in the war-torn and "scorched earth" regions reoccupied by the Allies in their successful prosecution and termination of the war. These power trains, Fig. 46, rated at 3750 kva, utilize locomotive-type boilers (for quick manufacture) especially designed to burn low-grade coal, averaging 6800 Btu per lb. Each ten-car train consists of two boiler cars, two tenders, switchgear car, three cooling-tower cars, turbine-generator car, and crew maintenance car.

For use in localities where water is scarce the cooling-tower cars are replaced by two radiator cars, Fig. 47.

RESEARCH

The report on impact stresses in track structures has brought to light important data that will permit of lighter structure design that should result in appreciable saving in constructional materials. The report covers some 900 tests on stresses produced by trains in motion over bridges with short spans at speeds up to 100 mph, in the case of Diesel-electric locomotives, and 85 mph where steam locomotives were involved. In all cases quantitative results indicated the superiority of the motor-driven axle over the conventional steam-locomotive axle with respect to impact stresses at speed.

Research and test work on suitable high-capacity coal-burning boilers for use with steam-turbine-driven locomotives continued through the past year but no findings are available for publication at this writing.

Work continues in the plants and laboratories of several manufacturers on gas-turbine plants suitable for railroad motive-power application. With the cessation of hostilities it is expected and hoped that these investigations will gain new impetus.

ACKNOWLEDGMENT

The committee gratefully acknowledges the assistance secured from the railroad press of the United States and England, particularly from the *Railway Gazette*, *Railway Age*, and *Railway Mechanical Engineer;* and from the locomotive and car builders, and railroads who furnished photographs and technical data.

The Future Supply of SCIENTIFIC PERSONNEL

By M. H. TRYTTEN

DIRECTOR, OFFICE OF SCIENTIFIC PERSONNEL, NATIONAL RESEARCH COUNCIL

THERE is abroad among us a new unity in the sciences and engineering. Perhaps this is due to the remarkable extent to which all branches of technology co-operated in some of the major undertakings of the war. I am sure that nothing remotely like the co-operation of the sciences in the Manhattan District projects ever occurred before. At Los Alamos, New Mexico, there were united in a common effort engineers of all branches, physicists, chemists, mathematicians, metallurgists, and even members of the life sciences and pathology. The integration of the efforts of these representatives of the separate disciplines was a source of satisfaction to those who observed it closely. Out of this type of wartime experience could come much fruitful work as a result of the unprecedented sharing of interests, but in quite another sense the experience has been good. Scientists and engineers have learned again that their problems are similar not only in technical matters, but in matters professional and public.

It is my hope that this wartime community of interest among scientists and engineers will continue in times of peace and will result in an emphasis on the essential oneness of science and technology. I believe that in the future the welfare of national technology will require much more emphasis on unity of the various branches of technology than on their differences.

I am not particularly concerned with any one science or one branch of engineering. We shall need in the future an unprecedented number of well-trained leaders in all fields of technology, be they research physicists, agronomists, statisticians, or chemical engineers. It is the outlook for this type of leadership we are concerned with. The war is over and the future lies before us somewhere on the other side of this business of reconversion. It is a fitting time to review the wartime experience to see what we have lost and what we have gained, what we have learned, and what mistakes we have made as we chart our course for the future. In the matter of our supply of scientists and engineers with which to meet the challenge of the future, it is now possible to discern somewhat more clearly where we stand and to point out where as a nation we set prudence aside in handling our personnel in this field during the war.

CONSIDERATIONS START WITH ATOMIC BOMB

It will not be astonishing that I begin with the atomic bomb. It is difficult to see how one can discuss any scientific matter from now on without first taking his bearings from this colossal historic landmark first displayed in Alomogordo Canyon. In fact, it is more than likely that the advent of atomic energy will become a landmark from which to survey future developments in all fields, even the political, economic, and social fields. But in the sciences and in the military fields it is an event of such tremendous implications that I am sure very few, even among those who should best be able to assess the effect of the impact of atomic energy on human affairs, have yet thought through its tremendous import. While I do not intend to try to do so in this paper, I must point out some of the bearing this work had on developments in the field of scientific personnel.

I have felt personally that strikingly little in the way of constructive thought on the real meaning of atomic energy has come out in the public press. On the contrary, it seems to me that too much has been said that might be calculated to anesthetize the public to the real shock of the event. Most of what one reads attempts to play down the importance of the event. It is as though the general public is to be protected from an alarm they might otherwise feel and which would be too dangerous for them to experience. One can, of course, understand the alarm of the military who are now up against a fourth dimension in military thinking and find it very hard indeed to reconcile themselves to the new reality. As *Life* puts it in an editorial, "The atomic bomb is the last and loudest of many revolutionary weapons developed in this war. So new are they that military science today is almost a chaos in which the military mind can be found clinging with more or less confidence to floating pieces of Clausewitz and Mahan." It seems to me it might have been wiser to recognize frankly for the benefit of the public the challenge of the bomb. Research alone can harness and control the atom now abroad among us, and the public must foot the bill. Congress will reflect the public mind. We would have done well not to let the public forget the bomb too soon, nor unduly minimize its importance in the world to come so that the public would fully appreciate the necessity for research on this new phenomenon and would authorize the necessary cost.

In the matter of scientific personnel, the atomic bomb has emphasized a conviction that scientists and engineers have held throughout the war, namely, that our national welfare demands a more realistic attitude toward able and talented youth and toward highly qualified personnel. This is a corollary to the theorems which have grown out of the war with regard to the place of science in modern life. These theorems may be found clearly stated in Dr. Vannevar Bush's report to the President, "Science—The Endless Frontier."

The first basic theorem growing out of this war is that science is now the major ingredient in military power. The theorem scarcely needs proof. It was not far from the truth even in the first world war. But in the war just past, science has been the decisive element. When the war ended we were in possession of extreme power in the atomic bomb, ultra speeds as exemplified by rocket weapons, and uncanny control in guided missiles, and in the proximity fuse which measures its own optimum point of detonation. Only a nation with highly developed technologies can make use of these new military tools, and countermeasures require an even higher order of technical competence.

SCIENCE THE NEW FRONTIER

The second theorem which has often been stated in the most recent times is that science is now our new frontier. We are as

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a nation committed to a philosophy of expansion. We believe in profits and investment as a means of keeping our economy growing in a healthy way and thereby providing remunerative activity for our people and a rising standard of living. We look with less favor on central government control as a substitute way of life. Our physical frontier, however, is largely explored and exploited. We do not depend upon international trade and economic imperialism. So our hope lies in our ever-increasing technical establishment. But this means that we must have an increasing supply of trained technical personnel. If the future economic welfare of our nation depends on the laboratory then the laboratory depends upon scientific personnel.

The corollary to these two theorems is inescapable. If our military and economic futures are dependent upon our supply of highly trained technical personnel, it must be of first importance to determine the policies that will insure adequate supplies of such personnel. This will inevitably involve a point of view that is new and perhaps repugnant to many Americans, but is inescapable, that highly qualified personnel either from the standpoint of aptitude or training are a national resource and must be so considered even though it may apparently result in discrimination which may seem unfair. We can no longer safely ignore this point of view. The demands of a technological world for specialists are steadily increasing and will continue to increase, and our supply of able and talented personnel is by no means unlimited. For the welfare of the nation it is necessary that those who have marked ability be permitted to develop their capabilities and, when trained, that they be permitted to exploit for the national good their own scientific competence. This war has demonstrated overwhelmingly and decisively that the scientist can serve best in his technical capacity. Any other use for him is waste of a precious national asset.

It is interesting to note how completely the Russians have adopted the concept. To the realistic and uninhibited Russians, the trained scientist is a desirable asset to be absorbed into Russian technology. Reports coming to us indicate that Russia is making efforts to influence a large number of German scientists and technicians to migrate to Russia where they are apparently being offered inducements to carry on their work. Reports indicate that substantial numbers of German scientists have already moved into Russian laboratories and the newspapers carry articles about nuclear physicists being flown to Russia. In our own case, we have gathered similar personnel in Germany into "protective custody," so called, and seem not to know what to do with them. As far as I can gather, we neither want to bring them to America, nor to permit them to rebuild the German technical establishment. So they remain very unhappy indeed in their places of confinement. Russia is likewise apparently going all out on a very extensive program of selection and training of her best youth. They have now in operation about 1500 technical institutes with enrollments of about 425,000. During the war their training of technical personnel continued unabated.

TECHNOLOGICAL DEVELOPMENTS SHORTENED THE WAR

In the United States we have persistently refused to adopt this point of view in spite of the fact that no country on earth has so conclusively demonstrated its fundamental soundness. It is generally conceded that radar gunfire control on our warships accounted for the overwhelming superiority of our surface naval warfare by allowing our Navy to operate at night. In at least two important battles this was the cause of brilliant victory at low cost. It is interesting to speculate on the number of additional ships and men that would have been necessary to win these battles had we not had this new development.

Only speculation is possible of course, but there seems little doubt that many Americans indeed owe their lives to the great tactical advantage produced by the equipment. Similarly the bombing through overcast is generally credited with saving the Normandy invasion from being attended by crushing loss.

Furthermore, this amazing radar development multiplied the power of our air arm manyfold and thereby hastened the defeat of Germany and Japan. The strategic advantage yielded by this equipment must be great indeed; if measured by the manpower equivalent in squadrons and platoons, it would be tremendous. One cannot help wondering how many additional thousands of selective-service inductions the services would have demanded had not this weapon been available.

It is a very practical question indeed for had we not had these things, victory could have been achieved only by slow and laborious struggles of greatly increased numbers of combat troops.

The possession by our forces of new devices such as high-grade incendiaries, flame throwers, stabilized turrets, proximity fuses, penicillin, DDT, and a host of other products and inventions, must in each case have reduced sharply the ultimate necessary armed strength needed for victory. Clearly each of the men whose efforts led to the development of these devices was more effective by many times toward victory through his work in the laboratory than he would have been had he served otherwise than through the exploitation of his scientific training. It is an indictment of our common sense that this simple fact has not been adequately recognized in our manpower policies.

One of the major handicaps was that those who understood the matter best had of necessity to be scientists who in trying to point out this simple truth could nevertheless always be charged with self-interest. Scientists, however, were leaning over backward to avoid the appearance of seeking special favors for scientists. It was not special favors they sought. It was rather that they knew the power inherent in the application of scientific principles and knowledge to the problems of the war. They alone could appreciate the waste in the failure to utilize properly a highly trained mind.

Throughout the entire war the struggle to retain young specialists in scientific work in support of the war involved only a few thousand men. Had the twenty or thirty thousand ablest scientists and engineers who were later inducted been reserved from the first for this type of work, it is likely that little of our wartime criticisms of selective service would have occurred. And yet, during this time, judging from the Medical Statistics Bulletin No. 3 of the Selective Service System, issued November 1, 1944, well over 500,000 men were rejected for service because their education was below a fourth-grade standard. In view of the selective-service theory that a replacement for most any job can be trained in 6 months, it seems striking that twenty or thirty thousand of these functional illiterates were not trained in 6 months to read and write so as to replace for the Army men who had spent 16 to 18 years' professional development in the technical branches.

Our persistent refusal to adopt this more realistic point of view could have had very serious consequences indeed had the war carried on longer or had not our technological strength been so great. But great as it was, widespread nullification of the effects of selective service by even the services themselves was necessary to prevent serious harm. Literally thousands of scientists and engineers were inducted and later returned to their former activities in uniform or in enlisted reserve status. If this avoidance of selective-service action had not occurred, such activities as the Manhattan District, Naval Laboratories, and the N.A.C.A. would have been very seriously handicapped.

It is a test of sound policy that unforeseen difficulties only emphasize its soundness. By this standard our policies on scientific manpower in this war were unsound indeed.

FORMULATING WARTIME MANPOWER POLICIES

It is not generally known that the present policy was set in the summer of 1942. At that time the issue was rather sharply drawn. During the fall of 1941, and the early months of 1942, committees had been brought together in Washington representing the best minds in science and education to advise on manpower policies and on the types and scope of training programs demanded by the war. The War Manpower Commission, the Office of Education, the Army and Navy, and the American Council on Education all co-operated in consideration of such problems through the appointment of advisory committees. It is unnecessary to discuss in detail the enlightened policies suggested by these various committees. Their deliberations and decisions constitute a very important and interesting chapter in the history of American science and education.

However, when the full recommendations of these various groups finally came to the level of decision, the War Manpower Commission appointed a committee representing War, Navy, Civil Service, W.P.B., and the W.M.C. to consider them and formulate a government policy with regard to training and utilization of highly specialized personnel. The report of this committee was approved by the W.M.C. on August 19, 1942. It contains in one of its nine recommendations the key to the whole later manpower history during the war. This recommendation reads "All able-bodied male students are destined for the armed forces. The responsibility for determining specific training for such students is a function of the Army and Navy."

Although couched in terms of training, this recommendation clearly foreshadowed the attitude prevailing thereafter during the war.

It was a clear-cut choice of policy. It indicated that the concept of maximum effectiveness of the national war effort would be definitely subordinated to the concept of the maximum numerical strength of the services. The acceptance of scientific research as a co-ordinate activity, which is so characteristic of modern industry, was entirely absent.

Following out this policy line, the War Manpower Commission in December abdicated its function as an allocation mechanism and Selective Service became frankly a procurement agency for the services. The budgeting of manpower ceased. Deferment regulations tightened. Student deferment was cancelled and eventually deferments of high-grade personnel were almost completely cancelled, first up to 22 years of age and then up to 26 years of age. It was clear that if deferment was to be permitted only to those indispensable to the war effort, as victory approached the likelihood of deferment would diminish. After V-Day, according to this concept, deferment should be no longer justifiable. That as you know has been the history. The very ablest of our young men, deferred through the war as indispensable, are now being inducted. Pending any rationalization of public policy or a complete cessation of draft, this will undoubtedly continue.

Such has been the history of events in our wartime experience with scientific personnel. The story is extremely important because it shows clearly that the issue is even yet not decided. It is yet not impossible that we shall have the draft for a long time to come. We shall have to postpone our resumption of training unless we can clearly establish that young men of suitable capability be exempted from military duties to resume training. It seems to me inevitable that this issue will continue to face us. Until it is met we shall suffer sharp losses to our scientific competence.

In attempting to forecast whether the supply of scientists and engineers in the future will meet the demand, it is necessary to make certain basic assumptions. It is, of course, clear that a major depression resulting in a widespread closing of the doors of industry would result in unemployment among technical personnel, at least eventually. It is also true that a marked lack of interest in research on the part of Congress would reduce one substantial activity which now promises to employ a large number of technically trained men. We shall not presuppose either of these developments. One does not plan for calamity. Either one of these two developments would be calamitous not only to the welfare of the United States but to the world.

FACTORS INDICATING INCREASED NEED FOR SCIENTIFIC PERSONNEL

Assuming a reasonable industrial growth in the United States and assuming that the present unmistakable interest in Congress in research is not to dissipate before bills can be passed, the demand for scientific and technical personnel should be sharply increased after the war. Some of the factors producing an increased demand for scientific personnel may be listed as follows:

1 The need for recovering lost ground due to the war. Very little, if any, research along fundamental lines has been done during the last five or six years.

In colleges and universities and in research foundations, the efforts of the academic scientists have been drawn to applied science for war purposes to a degree never before experienced. The restoration of this activity will involve much more than merely releasing scientists from war work. Research of this modern type is a group effort and requires many persons. The full reconstitution of fundamental research will occur only when adequate members of subordinate personnel are available, such as graduate assistants, and research fellows. Dr. Bush has called attention to the great extent of the lost ground during the war and sets up the nurturing of basic research as one of the main necessities of "Science—the Endless Frontier."

2 The rebuilding of faculties. Most prewar faculties in the sciences have been scattered and will in most cases not reassemble intact. Particularly, younger staff members have not been developed. In view of the great job of training which should be undertaken to rebuild our scientific competence, a large number of new staff members is needed by the universities. The expected rush of foreign students alone would make substantial additions necessary in college faculties.

3 The future of industrial research in the United States is clearly one of expansion. Several months ago we published the results of a very significant and informative survey conducted by the Industrial Research Institute. The survey showed unmistakable evidence that substantial increases in budget, in building space, and in personnel will be allotted to research. The increase is clearly to be greatest in smaller industries. More recent developments have clearly borne out the implications of this survey. Published plans by General Motors, General Electric, Standard Oil of New Jersey, Firestone, and others indicate the trend.

4 There is one other research activity which has not found its way into the headlines as yet. However, it undoubtedly will loom larger in importance in the future. During the war America has poured out its resources prodigally; in many cases this will unerringly point to the need for a great deal of research in substitute materials and in beneficiation of low-grade resources. Already this activity has led to plans for substantial research in the case of iron ore.

5 The wartime developments in the physical sciences have created a need for a tremendous amount of research in the field of medicine. Not only have new tools been made available to research programs but new dangers and new necessities have been created.

6 The plans of the Government are, of course, the great unknown since they depend upon the vision of Congress. Congress is now before the bar of history. What it does with the

plans for postwar science may establish for a long time to come the potentialities of our technology. A wise and generous participation by the Government in the stimulation of research and a prudent development of the atomic-energy research may lead the nation into a truly golden age. Excessive and unwise federal intervention in research, or a failure to support it, may develop. But if present indications are acceptable at face value, then we may look for increased federal interest in all types of research, but especially in atomic energy and in military research. Present plans, for example, call for doubling the scope of activity of the Naval Research Laboratory and for considerable extension of facilities for such laboratories as the Naval Ordnance Laboratories.

The services are acutely aware of the very elementary state of the development of measures and countermeasures involving atomic energy, not to mention guided missiles and rocket propulsion. The advent of these new weapons makes obsolete most wartime research. They introduce new orders of magnitude in power, in speed, and in controllability. Even basic researches along these lines will involve large numbers of technical personnel. A vigorous program could clearly absorb more personnel than is available. The next few weeks in Congress will determine very substantially the extent of demand for scientific personnel in the future. If Congress and the administration meet in any substantial way the challenge of the present, there will be a very great demand for personnel in comparison with prewar standards. Even without this federal interest in research, the industrial and academic interest alone promise to exceed prewar activity.

With regard to the supply of personnel, the evidence indicates a considerably reduced flow of freshly trained personnel into the ranks of the sciences and engineering.

HOW CAN THE GAP IN TRAINED SCIENTISTS BE FILLED?

We now must come to grips with the question of recovery. We must ask how soon and to what extent the gap in our supply of highly trained men may be partially or wholly filled in and how soon we may look for a return to the former rate of growth of our training program. The prewar history of American science is one of steady growth at a rate of increase of from 8 to 10 per cent a year, with faster growths in some fields. The great stimulus to chemistry in the last war, for example, was reflected in the rapid growth in the number of chemists trained in American universities after the war. This made possible a great industrial expansion, which again would occur after this war in other sciences if we had trained personnel. The question then is: How soon may we look for a resumption in the flow of graduate scientists?

Basic data on the situation indicate that a shortage of about 55,000 engineers is forecast by 1949. The drop in enrollment in the past three school years has been due to the stoppage of student deferment. But even so, the total number of those who left the universities to enter the armed services directly was not large. It is estimated that if all of these men were to enter the universities at this time, the number would not make up more than about 75 per cent of one year's enrollment. This is the case, for example, at Cornell University, according to Dean Hollister. Even a full return of all former students in engineering would therefore mean that the upper classes in the universities would not be crowded by G.I.'s. It is clearly questionable that all will return. There is considerable reason to believe that potential scientists who left the schools for the services are definitely fewer than in the case of engineering.

The question as to how many of these men will return to the colleges can best be estimated in terms of surveys conducted by the services. The Army Educational Division early in the year published the results of two surveys which had been conducted to secure information on which to base plans for army educational programs now being carried out at Shrivenham, England, at Biarritz, France, and at Florence, Italy. Besides these two reports there is a bulletin by the Research Branch of the War Department entitled, "What the Soldier Thinks," of which the educational plans of the soldier represent results of a survey conducted approximately two years ago.

These reports indicate certain approximations which may be drawn about the likelihood of return to school of military personnel. It is interesting to note that 75 per cent of the men indicate that they have thought very seriously of their postwar plans. In the bulletin "What the Soldier Thinks," it is reported that about 7 per cent of the men plan to return to full-time school. Of these, however, only $^{1}/_{8}$ of them plan to return to college. This means about 330,000 men. In comparison, the male college and university enrollment in 1939 was 815,000. This would mean that if all Army personnel were to return to school or college today, about 40 per cent of a year's enrollment would appear on the campuses. Similar figures are to be available in a very few weeks for the Navy, but as yet nothing is known to the author of the intentions of Navy personnel with regard to college.

Two points are worth mentioning: One is, of those men going back to full-time school only 8 per cent of them are married; 8 per cent is very probably considerably less than the percentage of persons married among college men in the Army and indicates that marriage is one of the deterrents to resumption of training. Another point is that this survey was made several months ago and since age is clearly a deterrent to resumption of training, these results may actually need revision downward.

ARMY DISTRIBUTION OF MANPOWER IN TERMS OF EDUCATION

In the other two Army reports there are two points of special interest, one of which concerns the distribution of men in the services in terms of their academic background. In the Army as a whole, for example, 26 per cent have graduated from high school but have had no college training, 10 per cent have had some college but were not graduated, and 3 per cent were graduated from college, a total of 39 per cent who have had at least a high-school education. This percentage progression is about the same as that which obtains in a cross section of white enlisted men in the Mediterranean theater and a little higher than is the case in some selected units of the infantry in the European theater, and in certain artillery and engineering units. If these units are typical, percentages of high-school graduates in these branches of service are as follows: Army generally 39 per cent, ground forces 33 per cent, artillery 29 per cent, engineers 35 per cent. However, in the Air Forces the level seems to be much higher. In a cross section of the 9th U. S. Air Force ground personnel, 40 per cent had finished high school but had no college degree, 14 per cent had some college training but were not graduated, and 3 per cent were graduated, for a total of 57 per cent who were graduated from high school. It is of interest to note that in a survey made in the 8th Air Force at a fighter base, the number expressing interest in full-time postwar education is 9 per cent, not much larger than for the Army as a whole, where about 7 per cent indicated an interest in full-time school.

I believe we should here emphasize that the mere replenishment of scientists and engineers is not adequate to restore the competence of our technology. There is a factor of youth which I believe should not be lost sight of. This factor becomes the more important, the more creative and imaginative the activity to be undertaken. We have learned in the sciences that it is important indeed to complete the basic training of our

(*Continued on page 151*)

GAS-TURBINE FUNDAMENTALS

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THE gas turbine is a prime mover embodying a compressor, a combustion chamber, and a turbine as illustrated in Fig. 1. Any combination of these elements working together is considered a gas turbine; however, the use of these components in conjunction with an Otto-cycle engine, a Diesel engine, a steam power plant, or other common forms of prime movers is not considered a gas-turbine power plant. Other components besides the compressor, combustion chamber, and turbine may be added to these and the resulting power plant is still considered a gas turbine. Such components are regenerators, compressor interstage coolers, turbine interstage combustion chambers, and split compressors or split turbines. The addition of these other components merely improves the performance or mechanical operation of the gas turbine and does not change its fundamental principles.

The gas turbine as illustrated in Fig. 1 operates on the familiar Joule (or Brayton) cycle which consists of adiabatic compression, constant-pressure burning, and adiabatic expansion. The adiabatic compression is normally accomplished in a compressor which may be either of the axial-flow type or the centrifugal type, or a combination of the two. The constant-pressure burning is normally accomplished in a combustion chamber although heating of the air may be done by indirect means such as a heat exchanger. The adiabatic expansion is normally accomplished by means of a turbine although other methods of removing the energy from the gas may also be used. The cycle of operation of the gas turbine is illustrated on the *p-v* diagram shown in Fig. 2. The air enters the compressor at 1 and is compressed adiabatically to 2. It then enters the combustion chamber and is heated at constant pressure to 3. In this state it enters the turbine and is expanded adiabatically to 4. Obviously, this is a simplified explanation since the compression is not 100 per cent efficient adiabatic compression, the heating does not occur without a slight pressure loss, and the expansion in the turbine is not 100 per cent efficient adiabatic expansion. However, the cycle is well illustrated by this ideal example.

For the purpose of this paper gas turbines are considered as being in two classes; the static gas turbine and the dynamic gas turbine. The static gas turbine is the one used for the familiar applications such as a stationary power plant, a marine power plant, a locomotive power plant, etc. The dynamic gas turbine is the one used for aircraft applications in which the performance is greatly affected by the forward speed of the gas turbine. The fundamentals of the static gas turbine are thoroughly discussed in the literature; some of the most recent publications are given in references (3), (4), (5), and (10).[1] The simple theory and some performance data of the static gas turbine are being repeated in this paper merely to provide a background and foundation for the theory and performance of the dynamic gas turbine. The simplest form of the static gas turbine is the simple-cycle gas turbine shown in Fig. 1.

The performance of gas turbines depends on the properties

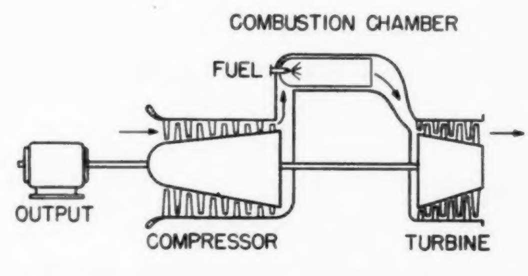

FIG. 1 SCHEMATIC DIAGRAM OF SIMPLE-CYCLE GAS TURBINE

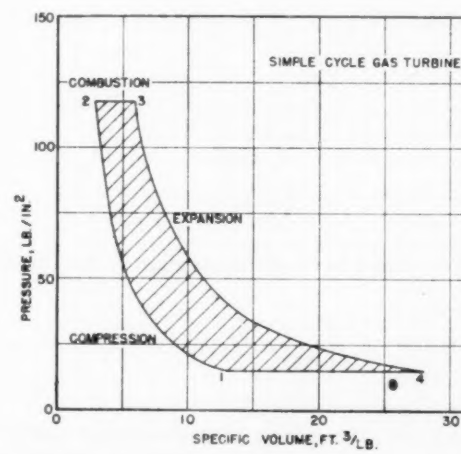

FIG. 2 PRESSURE-VOLUME DIAGRAM OF SIMPLE-CYCLE GAS TURBINE

of air and gases at pressures and temperatures which vary over a wide range. Therefore, to be strictly correct, the calculations of the performance of the gas turbines must take account of the variations of available energy, enthalpy, specific heat, and other properties with temperature and pressure, as well as with moisture content and composition. Since this is a laborious process, and since the properties of air and hot gas have only recently been accurately established, (6) and (7), simplifying assumptions are usually made. The simplest assumption, which may be called the first approximation, is that of an ideal air cycle using normal air throughout and perfect-gas laws. The second approximation, and the one used in this paper, is to assume normal air for the compressor, average properties for the air in the combustion chamber, and average properties for the hot gases in the turbine. In addition, it is assumed that the air in the compressor, the air in the combustion chamber, and the hot gas in the turbine obey the perfect-gas laws.

Based on these assumptions, the compression in the compressor results in a temperature rise of

$$\Delta T_c = \frac{XT_1}{\eta_c}$$

[1] Numbers in parentheses refer to the Bibliography at end of paper.

Contributed by the Aviation Division and presented at the Fall Meeting, Cincinnati, Ohio, Oct. 2-3, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

where X is obtained from the familiar expression

$$X = \left[\left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}} - 1\right]$$

The power required for this cycle is given by the following

$$P_c = \frac{778}{550}\, C_{pc} \Delta T_c w_a$$

The temperature rise in the combustion chamber is given by

$$\Delta T_b = \left(\frac{w_f}{w_a}\right)\left(\frac{Q_L\, \eta_b}{C_{pb}}\right)$$

The pressure loss through the combustion chamber is given by

$$\Delta p_o = p_2 - p_3 = C_b p_2$$

The temperature drop through the turbine is given by

$$\Delta T_u = \eta_u \psi T_3$$

where ψ is a function for expansion similar to the X function for compression

$$\psi = \frac{\left[\left(\frac{p_3}{p_4}\right)^{\frac{k-1}{k}} - 1\right]}{\left(\frac{p_3}{p_4}\right)^{\frac{k-1}{k}}}$$

The power developed by the turbine is given by the following equation.

$$P_u = \frac{778}{550}\, \Delta T_u C_{pu} w_a$$

(See appendix A for nomenclature.)

In analyzing the gas turbine throughout this paper the weight flow of hot gas from the combustion chamber and through the turbine is assumed to be equal to the weight flow of air entering the compressor. Actually, the hot-gas flow from the combustion chamber and through the turbine is greater than the air flow into the compressor by the amount of fuel burned. These two flows are being made equal with the assumption that the difference represents the mechanical loss. Thus it is not necessary to use a mechanical or coupling efficiency to take account of the heat-radiation losses, the bearing losses, the windage losses, etc., of the turbine, the combustion chamber, the compressor, and the power output.

The performance of all of the gas-turbine cycles throughout this entire paper is based on the standard efficiencies shown in Table 1. These efficiencies are used in all curves and discussions of this paper except when it is specifically indicated that one or more of them is changed or being considered variable.

The efficiencies shown in Table 1 are assumed values which are not necessarily obtained at present. However, in the author's opinion, these values represent a possibility for the future, with the development of the art proceeding as it is today. Since these efficiencies are being used for illustration of the fundamentals of gas turbines and not for actual performance representation, the performance data presented in this paper are not for any real gas turbine, either in existence or of a proposed design.

It is realized that these efficiencies are both higher and lower than those used by other authors in gas-turbine papers, (3), (4), (5), and (10). For example, reference (5) uses 0.80 for both compressor and turbine efficiencies. These values may be representative of present practice, considering the effects of dirt, carbon, deterioration of the vital parts, and the like, but it is expected that improvements will be made leading to the realization of the assumed efficiencies given in Table 1. The heat-exchanger effectiveness and pressure loss are controversial subjects, and an effectiveness of 0.75 might easily be obtained with a pressure loss of 0.08 instead of the values given in Table 1.

TABLE 1 STANDARD EFFICIENCIES FOR GAS-TURBINE CALCULATIONS

Compressor efficiency	η_c	0.85
Turbine efficiency	η_u	0.83
Turbine and jet efficiency	η_{uj}	0.90
Jet efficiency	η_j	0.98
Combustion-chamber pressure loss	C_b	0.03
Heat-exchanger effectiveness	η_h	0.50
Combustion efficiency	η_b	0.98
Ram efficiency	η_r	0.85
Regenerator pressure loss	C_h	0.05
Intercooler pressure loss	C_h	0.03

All of the curves and discussion of this paper are based on constant values for the properties of the air and hot gas as shown in Table 2. The properties of air are for "normal air" described in reference (1). The conditions of the air at altitude are taken from reference (2). The properties of the air in the combustion chamber are average values for air at about 900 F. The properties for the hot gas in the turbine are average values at about 1500 F, (6) and (7). Experience has shown that the use of these constant values in gas-turbine calculations gives performance which is very nearly the same as that obtained by the rigorous method employing actual properties, enthalpies, etc. This is true for only one set of conditions, but it is reasonably well true for other reasonably similar conditions.

TABLE 2 CONSTANT VALUES FOR GAS-TURBINE CALCULATIONS

Compression

$$C_{pc} = 0.243 \text{ Btu/lb deg F}$$
$$k = 1.3947 = C_p/C_v$$
$$\frac{k-1}{k} = 0.283$$
$$R_c = 53.4$$

Combustion

$$C_{pb} = 0.26 \text{ Btu/lb deg F}$$
$$Q_L = 18{,}550 \text{ Btu per lb}$$

Turbine

$$C_{pu} = 0.276 \text{ Btu/lb deg F}$$
$$k = 1.33 = C_p/C_v$$
$$\frac{k-1}{k} = 0.248$$
$$R_u = 53.6$$

Inlet air

$$T_{am} = 518.4 \text{ R}$$
$$P_{am} = 14.7 \text{ psi}$$

The basic parameter of performance to be used in this paper and as the ordinate for most of the curves is specific fuel consumption. The specific fuel consumption is the ratio of the fuel flow in pounds per hour to the output in horsepower.

$$w_{fp} = \frac{\text{lb (fuel)}}{\text{hp-hr}}$$

There is a definite relation between the thermal efficiency normally used for analysis of power plants and the specific fuel consumption as follows

$$\text{Thermal efficiency} = \frac{3600 \times 550}{w_{fp} \times 778 \times Q_L}$$

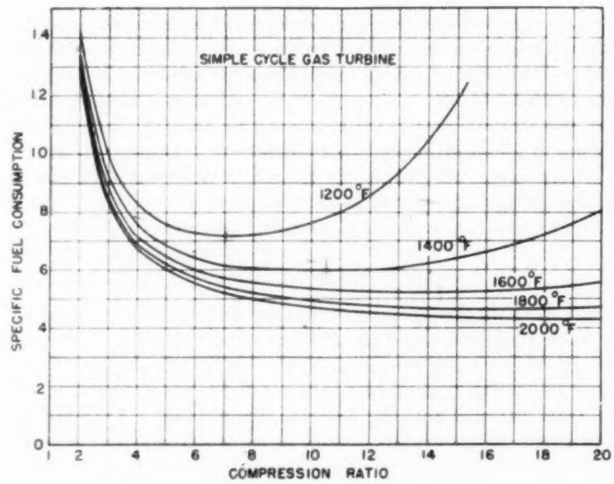

FIG. 3 EFFECT OF COMPRESSION RATIO AND TURBINE INLET TEMPERATURE ON SPECIFIC FUEL CONSUMPTION OF A SIMPLE-CYCLE GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCIES

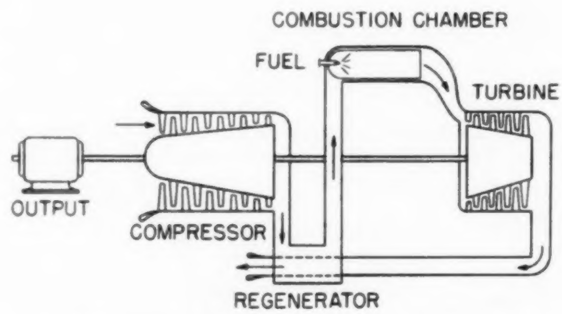

FIG. 4 SCHEMATIC DIAGRAM OF A REGENERATIVE-CYCLE GAS TURBINE

Very elementary considerations of the simple-cycle gas turbine show that a considerable amount of heat energy is being wasted in the exhaust from the turbine. If this heat energy could be used in place of fuel to help to heat the compressor discharge air, an improvement in specific fuel consumption can be obtained. By means of a heat exchanger called a regenerator, some of the waste heat can be so utilized. The performance of regenerators is normally considered in terms of their effectiveness as a heat exchanger. Effectiveness is the ratio of the temperature rise (or drop) to the inlet temperature difference between the fluid being heated (or cooled) and the heating (or cooling) fluid.

Fig. 4 is a schematic diagram of a regenerative-cycle static gas turbine. The regenerative cycle is obtained by adding a regenerator to the simple cycle. This is recognized as one of the most useful gas-turbine cycles and will probably have many applications. Fig. 5 shows the effect of regenerator effectiveness on the specific fuel consumption of a regenerative-cycle gas turbine. The curve with no regeneration is for the simple-cycle gas turbine. Fig. 5 clearly illustrates that for any given regenerator effectiveness there is a certain optimum pressure ratio at which minimum specific fuel consumption is obtained. This figure also shows that considerable gains in specific fuel consumption can be realized by using a regenerator. Furthermore, it shows that the optimum compression ratio for a regenerative cycle is considerably lower than for a simple cycle.

By rather elementary considerations of the gas-turbine cycle, it is apparent that improved performance can be obtained by intercooling between compressor stages and by reheating between turbine stages. In the limit these additions result in a cycle with isothermal compression, constant-pressure combustion, isothermal expansion, and regeneration to conserve waste heat. A cycle with intercooling between compressor stages, with reheating between turbine stages, and with a regenerator is called a complete cycle and is illustrated in Fig. 6. The specific fuel consumption of a complete cycle compared to the specific fuel consumption of a regenerative cycle and of a simple

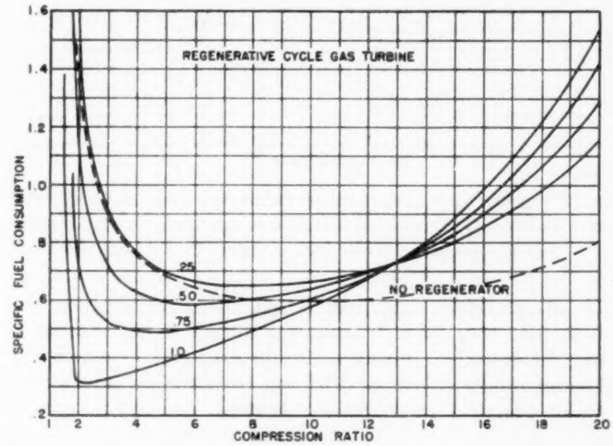

FIG. 5 EFFECT OF REGENERATOR EFFECTIVENESS AND COMPRESSION RATIO ON THE SPECIFIC FUEL CONSUMPTION OF A REGENERATIVE-CYCLE GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCIES (T_3 = 1400 F)

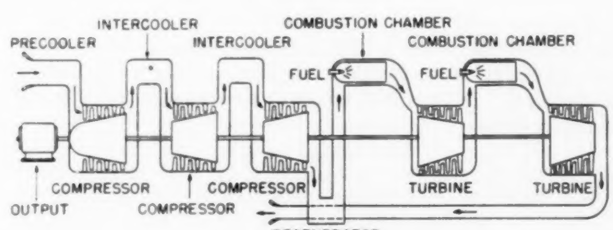

FIG. 6 SCHEMATIC DIAGRAM OF A COMPLETE-CYCLE GAS TURBINE

cycle is shown in Fig. 7 for various pressure ratios. Unfortunately, it is not possible to realize the good performance which could be obtained by isothermal compression and isothermal expansion. Furthermore, the pressure drops through intercoolers, combustion chambers, and regenerators detract considerably from the performance which could be obtained if these pressure drops were negligible. Even so, a very definite gain is shown for the complete cycle over the regenerative cycle, by about as much as the regenerative cycle is better than the simple cycle. Thus it appears that as the gas turbine becomes more complex, its performance is improved, although this improvement is obtained only at the expense of a greater amount of capital equipment and a considerable increase in the maintenance costs. However, in large power plants, the improvement in specific fuel consumption may be sufficient to warrant the increased capital investment and increased maintenance cost.

When the gas turbine is used for propulsion of aircraft or for other purposes in which the forward velocity is high, two new effects must be considered. These are the effect of the ramming intake and the effect of the jet discharge. When these

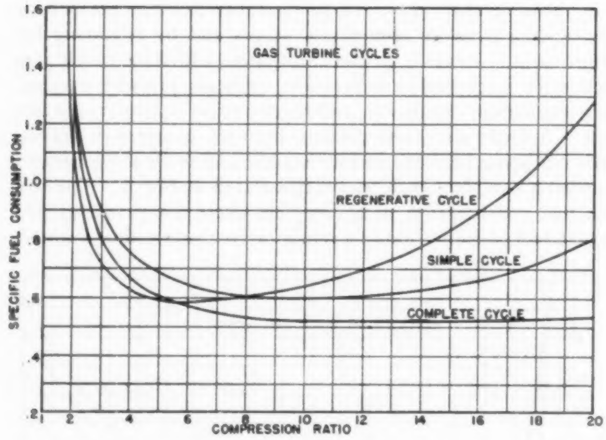

FIG. 7 EFFECT OF COMPRESSION RATIO ON THE SPECIFIC FUEL CONSUMPTION OF A COMPLETE-CYCLE GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCIES (T_3 = 1400 F)

two effects become appreciable and affect performance, the gas turbine is called a dynamic gas turbine to differentiate it from the static gas turbines already discussed in which the ramming intake and the jet discharge are not important factors. For all practical purposes, the dynamic gas turbine can be considered the gas turbine for aircraft propulsion.

The ramming intake increases both the temperature and the pressure at the compressor inlet. The temperature rise is the full temperature rise equivalent to the forward speed of the gas turbine and is given by

$$\Delta T_r = \frac{V^2}{2gJC_{pe}}$$

The pressure rise is not as efficient as the temperature rise and only a portion of the pressure rise theoretically available can be obtained. In aircraft literature, the ram efficiency is defined as follows

$$p_1 - p_{am} = \eta_r q_c$$

Where the theoretical rise q_c is obtained from

$$\left[(q_c/p_{am} + 1)^{\frac{k-1}{k}} - 1\right]T_{am} = \Delta T_r$$

The performance of the dynamic gas turbine is adversely affected by the ram temperature rise; however, the performance is improved by the ram pressure rise. Since the temperature rise is automatic, the only controllable factor is the ram efficiency which has a very important effect on the performance as will be illustrated.

The available energy at the turbine inlet can be used both for turbine power and for jet power, providing the forward speed of the gas turbine is high enough so that some power can be developed by the jet thrust. Therefore a combined turbine and jet efficiency, η_{uj}, is used for determining the proportion of the available energy at the turbine inlet which is realized in the turbine and in the jet. Thus the temperature drop through the turbine and jet is

$$\Delta T_u + \Delta T_j = \eta_{uj}\psi T_3$$

where

$$\psi = \frac{\left[\left(\frac{p_3}{p_{am}}\right)^{\frac{k-1}{k}} - 1\right]}{\left(\frac{p_3}{p_{am}}\right)^{\frac{k-1}{k}}}$$

This definition of combined turbine and jet efficiency results in an apparent turbine efficiency of η_{uj} when no energy is being used in the jet which is somewhat unrealistic. However, when reasonable jet velocities are used, as is necessary in a real gas-turbine design, this combined turbine and jet efficiency is a reasonable approximation.

The power developed by the turbine is the same as given in the foregoing for the static gas turbine.

The jet velocity is obtained from the relation

$$v_j = \sqrt{2gJ\,C_{pu}\,\eta_j\,\Delta T_j}$$

The dynamic gas turbine is moving with sufficient speed so that the power required to take the air on board and accelerate it to the speed of the gas turbine must be considered. Likewise, the power developed by the jet due to its rearward velocity from the gas turbine becomes appreciable. This can be considered the elementary theory of jet propulsion and is based on Newton's second law of motion which says that thrust is equal to the time rate of change of momentum. On this theory, the ram power is

$$P_r = \frac{V^2 w_a}{550g}$$

Likewise, the jet power is

$$P_j = \frac{V v_j w_g}{550g}$$

Fig. 8 is a schematic diagram of a dynamic gas turbine for propeller drive. The air enters the ramming intake and is

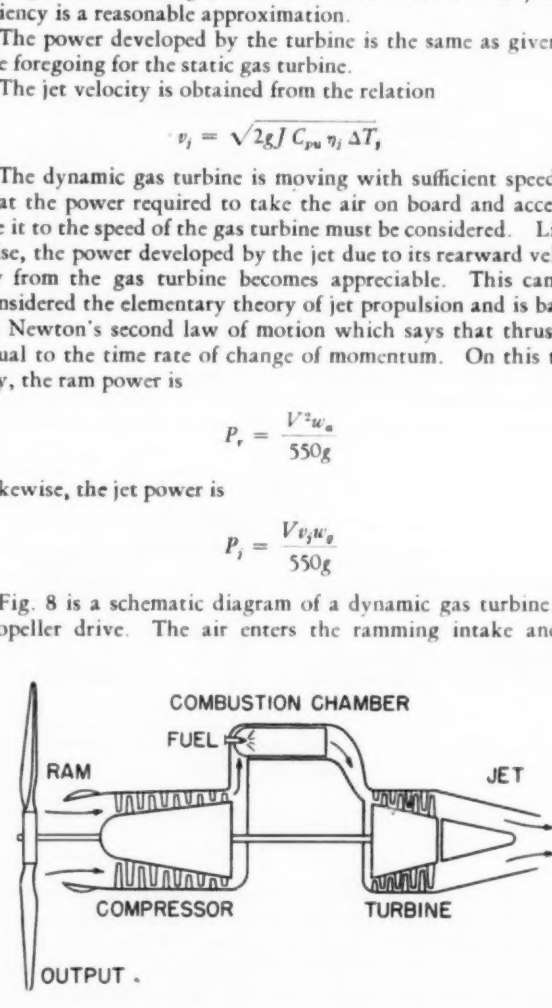

FIG. 8 SCHEMATIC DIAGRAM OF A PROPELLER-DRIVE GAS TURBINE

compressed and heated by ram as has been described owing to the forward speed of the gas turbine. It then passes through the compressor, the combustion chamber, and the turbine. From the turbine, it is discharged through a jet nozzle to the rear. Output power developed is delivered to a propeller. Obviously, this gas turbine must be charged with the power lost due to ram and must be given credit for the power developed by the jet. Thus the power output is the shaft power plus the propulsive jet power minus the ram power. In all considerations of the propeller-drive gas turbine, the power output is based on the shaft power and does not include a propeller efficiency. In a real application, the useful output is obtained by multiplying the shaft power by the propeller efficiency, adding the jet power, and subtracting the ram power.

The performance of a propeller-drive gas turbine is shown in Fig. 9. This shows the effect of forward speed and compression ratio on the specific fuel consumption of a propeller-drive gas turbine. This curve was made by assuming that the jet power is equal to the ram power, which, of course, is an assumption. Theoretically, the turbine energy can be divided

between the propeller and the jet in any desired proportion. The effect of division of energy between the propeller and the jet on the specific fuel consumption of a propeller-drive gas turbine is shown in Fig. 10. This shows that the optimum performance is obtained at a certain energy distribution between the propeller and the jet depending on the forward speed. Further analysis of this has shown that this optimum point of specific fuel consumption occurs where the jet power is equal to the ram power. Thus the curves of Fig. 9 are for the optimum distribution of energy between the propeller and the jet. Since it is impractical to design a turbine without some leaving loss (or energy in the exhaust) these curves are only of theoretical interest below about 15 per cent energy in the jet.

Since the propeller-drive gas turbine is particularly for aircraft application, it might be expected that altitude will have some effect on performance. The output of a given gas turbine is materially affected by the reduction in density at high altitudes. This, however, is a mechanical consideration and is beyond the scope of this paper. There is also a thermodynamic effect due to the reduction in temperature with increasing altitude. This effect is illustrated in Fig. 11 which shows the effect of altitude on the specific fuel consumption. This entire effect is due to inlet temperature change and it is not due to pressure change. This shows that optimum performance of a propeller-drive gas turbine can always be obtained at the highest altitude or at the lowest air temperature obtainable.

In the limit of zero shaft power when all of the energy is used in the jet discharge, the propeller-drive gas turbine becomes a pure jet-propulsion gas turbine. Fig. 12 is a schematic diagram of a jet-propulsion gas turbine. In this cycle the air is compressed in a ramming intake. It then passes through a compressor, a combustion chamber, and a turbine. The exhaust from the turbine is discharged rearward through a jet nozzle. The power of the turbine is just sufficient to

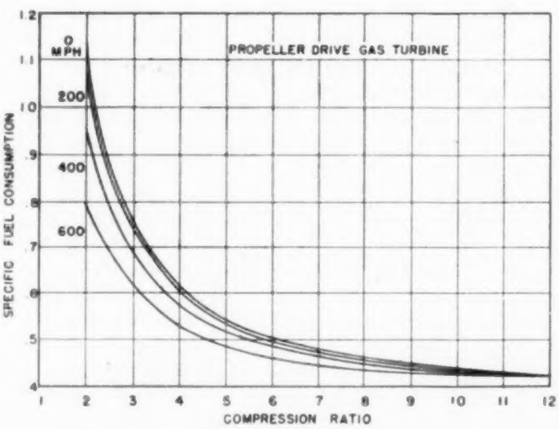

FIG. 9 EFFECT OF FORWARD SPEED AND COMPRESSION RATIO ON THE SPECIFIC FUEL CONSUMPTION OF A PROPELLER-DRIVE GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCIES. ($P_r = P_j$; $T_3 = 1500$ F)

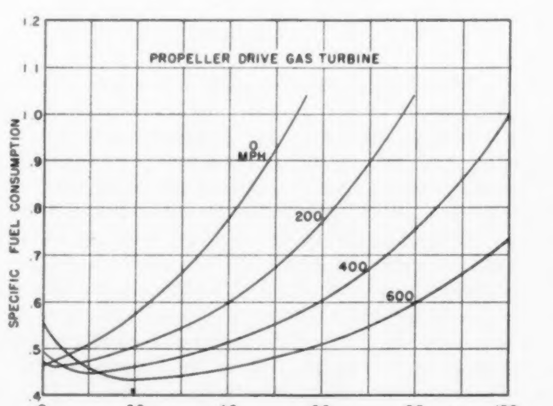

FIG. 10 EFFECT ON THE SPECIFIC FUEL CONSUMPTION OF THE DIVISION OF ENERGY BETWEEN THE PROPELLER AND THE JET OF A PROPELLER-DRIVE GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCIES. ($P_2/P_1 = 8$; $T_3 = 1500$ F)

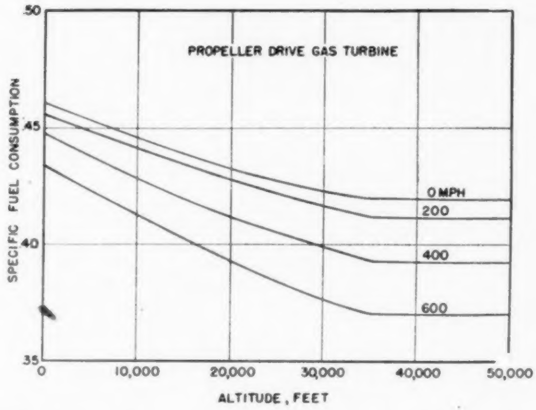

FIG. 11 EFFECT OF ALTITUDE ON THE SPECIFIC FUEL CONSUMPTION OF A PROPELLER-DRIVE GAS TURBINE. ($P_r = P_j$; $p_2/p_1 = 8$; $T_3 = 1500$ F)

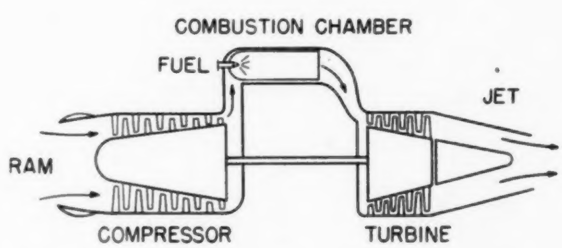

FIG. 12 SCHEMATIC DIAGRAM OF A JET-PROPULSION GAS TURBINE

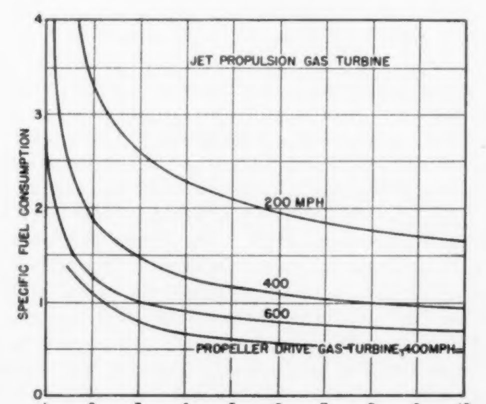

FIG. 13 EFFECT OF COMPRESSION RATIO AND FORWARD SPEED ON THE SPECIFIC FUEL CONSUMPTION OF A JET-PROPULSION GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCIES. (PROPELLER EFFICIENCY = 0.86; $T_3 = 1500$ F)

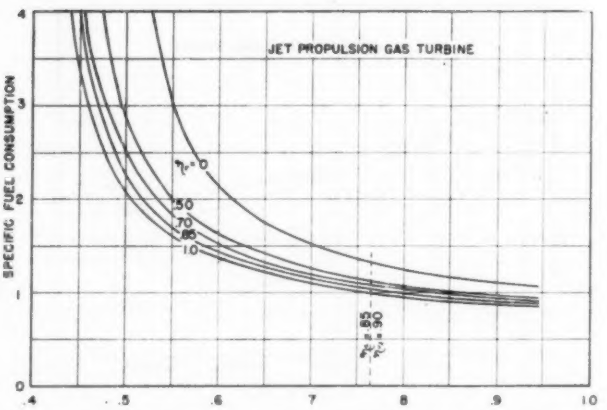

FIG. 14 EFFECT OF COMPRESSOR, TURBINE, AND RAM EFFICIENCY ON THE SPECIFIC FUEL CONSUMPTION OF A JET-PROPULSION GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCES. ($\eta_c/\eta_{uj} = 0.945$; $V = 500$ MPH; $T_3 = 1500$ F; $P_2/P_1 = 4$)

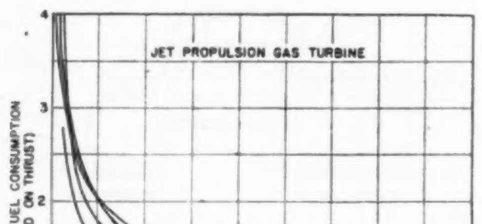

FIG. 15 EFFECT OF COMPRESSION RATIO AND FORWARD SPEED ON THE SPECIFIC FUEL CONSUMPTION BASED ON THRUST OF A JET-PROPULSION GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCES. ($T_3 = 1500$ F)

drive the compressor. Although this is a special case of the propeller-drive gas turbine, it is a very important gas-turbine cycle and so will be discussed and illustrated in some detail. Fig. 13 shows the effect of compression ratio and forward speed on the specific fuel consumption. Shown on the same figure is the curve for a propeller-drive gas turbine at 400 mph for which the specific fuel consumption has been increased by dividing by the propeller efficiency in order to put it on a comparable basis. The propeller efficiency is assumed to be 0.86, which is a reasonable propeller efficiency at sea level and 400 mph, according to reference (11). The specific fuel consumption of the jet-propulsion gas turbine is based on propulsive power, whereas the specific fuel consumption of the propeller-drive gas turbine must be divided by the propeller efficiency to be based on propulsive power which brings the actual performance of the two gas turbines much closer. At very high speeds, the propeller efficiency falls off with speed increase, and the jet-propulsion gas turbine gets better with speed increase. Thus there is some forward speed above which the specific fuel consumption based on net propulsive power of the jet-propulsion gas turbine is better than that of the propeller-drive gas turbine, or of other forms of power plants having comparable performance which may be used with a propeller.

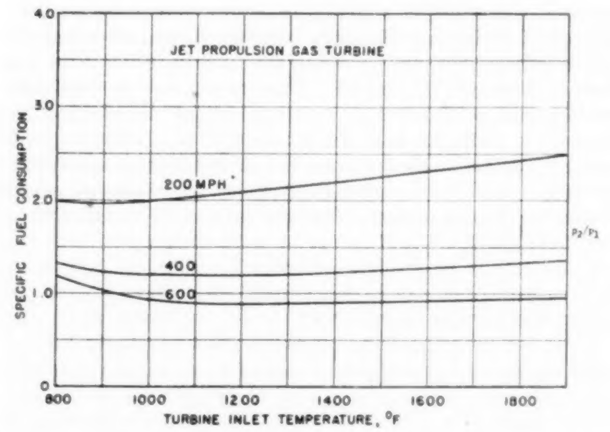

FIG. 16 EFFECT OF TURBINE INLET TEMPERATURE AND FORWARD SPEED ON THE SPECIFIC FUEL CONSUMPTION OF A JET-PROPULSION GAS TURBINE. THESE CURVES ARE BASED ON ASSUMED EFFICIENCES. ($p_2/p_1 = 4$)

Fig. 14 shows the effect of turbine and compressor efficiency on the specific fuel consumption of a jet-propulsion gas turbine. Various curves are shown for various ram efficiencies. This shows clearly the importance of obtaining the highest possible ram efficiency if good specific fuel consumption is to be obtained. This curve was made up by assuming that the ratio of the compressor efficiency to the turbine and jet efficiency was constant at the standard value of 0.945. The same curves are approximately true for other ratios of compressor and turbine efficiency. The output of a jet-propulsion gas turbine falls off with increasing altitude because of reduced density. However, the temperature effect is not as pronounced for the jet-propulsion gas turbine as it is for the propeller-drive gas turbine as was shown in Fig. 11.

In dealing with jet propulsion, it is obvious that there is no power output when the gas turbine is tested in a test cell, because the gas turbine is not in motion. Therefore, another parameter is used with jet propulsion and is called specific fuel consumption based on thrust. This is defined as the fuel flow in pounds per hour divided by the net thrust developed by the gas turbine in pounds.

$$w_{f_n} = \frac{\text{lb (fuel)}}{\text{lb (net thrust) hr}}$$

By using this specific fuel consumption based on thrust, it is possible to obtain data in test cells and make extrapolations to actual operating conditions. Fig. 15 illustrates the specific fuel consumption based on thrust as a function of compression ratio for various forward speeds. This is the only curve for jet propulsion on which zero miles per hour forward speed is plotted. Thus tests can be run in a cell with the gas turbine static and the curve for zero miles per hour can be obtained. Extrapolations to actual operating conditions are much easier on this basis for thrust than are extrapolations of power.

As shown in Fig. 3 the performance of a static gas turbine is improved by using higher turbine inlet temperatures. The same is true also for a propeller-drive gas turbine. This, however, is not true for jet-propulsion gas turbines because the higher turbine inlet temperatures result in higher jet velocities and lower propulsive efficiencies. Fig. 16 illustrates the effect of turbine inlet temperature on the specific fuel consumption of a jet-propulsion gas turbine for various forward speeds. This shows that for any given forward speed there is an optimum

turbine inlet temperature for minimum specific fuel consumption. This turbine inlet temperature occurs at relatively low temperatures compared to the practical operating temperatures for gas turbines. For example, at 400 mph the minimum specific fuel consumption occurs at about 1100 F, and at 600 mph the minimum specific fuel consumption occurs at approximately 1200 F turbine inlet temperature. Fortunately, the curves are fairly flat for higher temperatures, so the choice of turbine inlet temperature is not critical and depends on other factors.

In order to establish a basis for evaluation of the numerical values of specific fuel consumption presented in this paper, the performance of other well known prime movers can be transformed into a comparable specific fuel consumption. The Otto-cycle aviation engine has a specific fuel consumption ranging from 0.43 to 0.50 lb (fuel) per hp-hr and averaging about 0.45. The best that has been realized to date with these engines is about 0.40 for ideal operating conditions of a new engine. These figures are not comparable to the performance of a jet-propulsion gas turbine because they are based on test-stand shaft power output. To be comparable, they must be converted to a propulsive power basis which means that the propeller efficiency and the cooling-air drag power must be taken into account. This would increase these figures about 15 per cent to an average of about 0.52 lb (fuel) per hp (propulsive) hr. The modern central-station steam-generating plant has a minimum heat rate of about 10,000 Btu (fuel) per kwhr which corresponds to a specific fuel consumption of 0.40 lb (fuel) per hp-hr. The combined mercury-vapor and steam plant has attained as low as 9158 Btu (fuel) per kwhr which is a specific fuel consumption of 0.37 lb (fuel) per hp-hr, (8). The modern Diesel engine obtains as high as 35 per cent thermal efficiency which corresponds to a specific fuel consumption of 0.39 lb (fuel) per hp-hr, (9). By comparing these figures with the curves presented in this paper, it is seen that the gas turbine is rapidly approaching the state of development where it will be competitive with these other types of prime movers. However, the gas turbine is shooting at moving targets which always seem to move ahead when the gas turbine seems to be getting close.

As shown in the early part of this paper, the addition of regenerators, intercoolers, etc., to the simple cycle improves the performance of the simple-cycle gas turbine. (See Figs. 3, 5, and 7.) In like manner, the performance of the propeller-drive gas turbine can be improved by these additional components. Also, the jet-propulsion gas turbine can be improved somewhat by these additional elements, although not as much as the propeller-drive gas turbine. Thus the dynamic gas turbine for aircraft propulsion offers interesting possibilities for the present and near future. It must be remembered that the performance data presented in this paper are based on assumed efficiencies, hence the performance data are not for any existing or proposed gas turbines.

The author wishes to acknowledge the help given him by his colleagues in the General Electric Company which has made possible the preparation of this paper. Messrs. R. A. Novak, J. E. Foisy, and C. E. Danforth are thanked especially for the preparation of the curves used in this paper.

REFERENCES

1 "Engineering Computations for Air and Gases," by S. A. Moss and C. W. Smith, Trans. A.S.M.E., vol. 52, 1930, paper APM-52-8.

2 "Standard Atmosphere—Tables and Data," by W. S. Diehl, N.A.C.A. Report no. 218.

3 "The Modern Gas Turbine," by R. Tom Sawyer, Prentice Hall, New York, 1945.

4 "Gas Turbines and Jet Propulsion for Aircraft," by G. Geoffrey Smith, Aerosphere, Inc., New York, 1944.

5 "The Basic Gas-Turbine Plant and Some of its Variants," by J. Kenneth Salisbury, MECHANICAL ENGINEERING, vol. 66, 1944, pp. 373–383.

6 "The New Specific Heats," by R. C. H. Heck, MECHANICAL ENGINEERING, vol. 62, 1940, pp. 9–12, with additional discussion in MECHANICAL ENGINEERING, vol. 63, 1941, pp. 126–135.

7 "A Table of Thermodynamic Properties of Air," by J. H. Keenan, and J. Kaye, *Journal of Applied Mechanics*, Trans. A.S.M.E., vol. 65, 1943, p. A-123.

8 "The Mercury-Vapor Process," by A. R. Smith and E. S. Thompson, Trans. A.S.M.E., vol. 64, 1942, pp. 625–646.

9 "Marine Engineering," by H. L. Seward, Society of Naval Architects and Marine Engineers, New York, 1944, vol. 1, p. 3, and vol. 2, p. 21.

10 "Gas Turbines and Turbosuperchargers," by S. A. Moss, Trans. A.S.M.E., vol. 66, 1944, pp. 351–371.

11 "High-Speed Aircraft," by F. Flader and E. Rushmore. *Journal of the Aeronautical Sciences*, vol. 7, no. 6, 1940, pp. 235–243.

APPENDIX A

NOMENCLATURE

p = pressure, total,[a] psi
T = temperature, total,[a] deg R
p_{am}, T_{am} = atmosphere, ambient
p_1, T_1 = compressor inlet
p_2, T_2 = compressor discharge
p_3, T_3 = turbine inlet
p_4, T_4 = turbine discharge
w_a = air flow, lb per sec
w_g = gas flow, lb per sec
w_f = fuel flow, lb per sec
ΔT_c = compressor temperature rise, F
ΔT_b = combustion-chamber temperature rise, F
ΔT_u = turbine temperature drop, F
ΔT_r = ram temperature rise, F
ΔT_j = jet temperature drop, F
η_c = compressor efficiency
η_u = turbine efficiency
η_{uj} = turbine and jet efficiency
η_j = jet efficiency
η_r = ram efficiency
η_b = combustion efficiency
η_h = heat-exchanger efficiency (effectiveness)
C_b = combustion pressure-loss coefficient
C_h = regenerator, intercooler, precooler, etc., pressure-loss coefficient
C_{pu} = specific heat at constant pressure in turbine, Btu/lb deg F
C_{pc} = specific heat at constant pressure in compressor, Btu/lb deg F
C_{pb} = specific heat at constant pressure in combustion chamber, Btu/lb deg F
R_u = turbine gas constant
R_c = compressor gas constant
w_{fp} = specific fuel consumption, lb (fuel) per hp-hr
w_{fn} = specific fuel consumption (thrust), lb (fuel) per lb (net thrust) hr
Q_L = heating value of fuel, lower, Btu per lb
P_c = compressor power, hp
P_u = turbine power, hp
P_j = jet power, hp
P_s = shaft output power, hp
P_r = ram power, hp
J = Joule's constant, 778 ft lb per Btu
g = acceleration of gravity, 32.2 lb per sec per sec
Δp_b = combustion-chamber pressure loss, psi
Δp_h = regenerator and heat-exchanger pressure loss, psi
V = airplane forward speed, ft per sec
q_o = dynamic pressure rise, psi
v_j = jet velocity, ft per sec
k = ratio of specific heats, C_p/C_v

[a] Note that all pressures and temperatures throughout this paper are total, except p_4 which is a static pressure.

AUTOMATIC-CONTROL TERMS

Compiled by Committee on Terminology of Industrial Instruments and Regulators Division, A.S.M.E.

THE need for a consistent and usable set of terms applying to industrial process control has been evident for a number of years. Suppliers and users alike frequently find it difficult to discuss the subject without misunderstandings which result from the lack of a common language. Further, in the writing of specifications for new equipment and of directions for its use, it is desirable to have at hand a standard set of terms. The list of automatic-control terms and definitions which follows was prepared by the Terminology Committee of the Industrial Instruments and Regulators Division of The American Society of Mechanical Engineers. An attempt has been made to adhere to best current usage, with such modifications as may be required to make the list consistent and comprehensive. In its present form, the list embodies revisions based on comments and suggestions which were received in response to publication of a preliminary list.[1]

This list covers most of the terms commonly employed in the field of automatic control for industrial processes. The definitions are directed primarily to this field, but in many cases are sufficiently broad to have wider application. The order in which the terms appear is merely one of convenience. For a clear and comprehensive understanding of any particular term, it will often be necessary to consider associated terms elsewhere in the list. In all cases, the definitions apply to mechanisms and elements which perform their designed functions perfectly.

Automatic controllers are here considered to be only those devices which are constructed and capable of being used in such a way that the complete installation, including the process under control, constitutes a closed loop of action and counteraction operating without human aid.

Some phenomenon of the process, called the controlled variable, produces an initial effect upon the measuring means of the controller. If this effect does not correspond with the value of the controlled variable which the automatic controller operates to maintain, the measuring means institutes corrective action. The corrective action restores, or tends to restore, the value of the controlled variable to the desired value.

Unless this entire loop of initial action and corrective action is present, automatic control is not realized. Anything less than this constitutes some form of automatic operation, rather than automatic control.

[1] "Process Control Terms," MECHANICAL ENGINEERING, vol. 66, 1944, pp. 205–206.

Alphabetical List of Terms

Classified List of Automatic-Control Terms and Definitions

100 AUTOMATIC CONTROLLERS AND CONTROL SYSTEMS

101 An *Automatic Controller* is a mechanism which measures the value of a variable quantity or condition and operates to correct or limit deviation of this measured value from a selected reference. It includes both the measuring means and the controlling means. (*Automatic Regulator* is a synonymous term.)

102 A *Self-Operated Controller* is one in which all the energy necessary to operate the final control element is derived from the controlled medium through the primary element.

This type of automatic controller must have both self-operated measuring means and self-operated controlling means.

103 A *Relay-Operated Controller* is one in which the energy transmitted through the primary element is either supplemented or amplified for operating the final control element by employing energy from another source.

This type of automatic controller may have either a self-operated measuring means and a relay-operated controlling means, or a relay-operated measuring means and a self-operated controlling means, or a relay-operated measuring means and a relay-operated controlling means.

104 The *Desired Value* is the value of the controlled variable which it is desired to maintain.

105 The *Set Point* is the position to which the control-point-setting mechanism is set.

Where the automatic controller possesses a set-point scale, the set point is the scale reading translated into units of the controlled variable. Where a setting scale is not provided, the set point is the position of the control-point-setting mechanism translated into units of the controlled variable.

In some types of automatic controllers, for example, those with two-position differential gap, floating with neutral or proportional-position action, the set point is related to the position of a range of values of the controlled variable. The set point is then generally selected as the center of this range of values.

The set point may be varied manually or by automatic means, such as in time-schedule or ratio control.

106 The *Control Point* is the value of the controlled variable which, at any instant, the automatic controller operates to maintain.

In some types of automatic controllers, for example, those with two-position differential gap or floating with neutral controller action, the control point becomes a control range of values of the controlled variable rather than a single value.

In positioning-type controller action, the control point may lie anywhere within a predetermined range of values of the controlled variable. The control point may then differ from the set point by the amount of offset.

In floating with zero neutral zone controller action, the control point and the set point coincide.

200 BASIC CHARACTERISTICS

Delaying or retarding effects associated with industrial process control are caused by capacitance, resistance, and dead time (either separately or in combination) and have often been designated as various forms of "lag." These three terms cover the basic concepts involved and, in the interest of clarity, should be used in place of the less exact term "lag."

201 *Capacity* is a measure of the maximum quantity of energy or material which can be stored. It is measured in units of quantity.

The volume capacity of an open tank, for example, is the maximum volume of liquid it will hold without overflowing. The weight capacity of a compressed-air tank is the maximum weight of air which it will hold without exceeding safe pressure.

202 *Capacitance* is the change in quantity contained per unit of change in some reference variable. It is measured in units of quantity, divided by the reference variable.

The energy or material being contained and the reference variable determine the type of capacitance. Process capacitance may involve different quantities and reference variables, and several types may exist together in one process.

The volume capacitance of an open tank with respect to head is the change of volume of stored liquid per unit change of head, which is equivalent in value to the area of the liquid surface. It should be noted that if the shape of the tank causes the liquid surface area to vary with change of head, the capacitance will likewise vary with head.

The weight capacitance of a gas-filled tank with respect to pressure is the change of weight of stored gas per unit change of pressure.

203 *Resistance* is opposition to flow. It is measured in units of potential change required to produce unit change in flow.

204 *Dead Time* is any definite delay period between two related actions. It is measured in units of time.

300 PROCESSES, THEIR ELEMENTS AND CHARACTERISTICS

301 A *Process* comprises the collective functions performed in and by the equipment in which a variable is to be controlled.

"Equipment," as embodied in this definition, should be understood not to include any automatic-control equipment.

302 *Self-Regulation* is a sustained reaction inherent in the process which assists or opposes the establishment of equilibrium.

303 The *Controlled Variable* is that quantity or condition which is measured and controlled.

The controlled variable is a condition or characteristic of the controlled medium. For example, where temperature of water in a tank is automatically controlled, the controlled variable is temperature, and the controlled medium is water.

304 The *Controlled Medium* is that process, energy, or material in which a variable is controlled.

See example for 303.

305 The *Manipulated Variable* is that quantity or condition which is varied by the automatic controller so as to affect the value of the controlled variable.

The manipulated variable is a condition or characteristic of the control agent. For example, where a final control element changes the rate of fuel-gas flow to a burner, the manipulated variable is rate of flow, and the control agent is fuel gas.

306 The *Control Agent* is that process, energy, or material of which the manipulated variable is a condition or characteristic.

See example for 305.

400 CHARACTERISTICS OF AUTOMATIC CONTROL

401 *Error* is the difference between the instantaneous value and the desired value of the controlled variable.

402 *Deviation* is the difference between the instantaneous value of the controlled variable and the value of the controlled variable corresponding with the set point.

403 *Offset* is a sustained deviation due to an inherent characteristic of positioning-controller action and is the difference existing at any time between the control point and the value of the controlled variable corresponding with the set point.

404 *Corrective Action* is predetermined variation of the manipulated variable initiated by a deviation.

405 *Cycling* is a periodic change of the controlled variable from one value to another. ("Oscillation" is a synonymous term.)

There are three types of cycling, i.e., cycling in which the amplitude gradually decreases, cycling in which the amplitude is constant, and cycling in which the amplitude gradually increases.

500 TYPES OF AUTOMATIC-CONTROLLER ACTION

For simplicity, the definitions which follow are stated in terms relating controller action to "position of a final control element." However, these definitions apply equally to equivalent controller action related to (1) "value of the manipulated variable," and (2) "value of set point of another controller."

For types of automatic-controller actions, which are defined as having a linear relation between a function of the controlled variable and position or rate of motion of the final control element, it is assumed that the linear relation may be referred to either "motion or force of the last element in the measuring means," as well as to "value of the controlled variable."

It is assumed that the automatic controller operates ideally, that is, it is capable of detecting infinitesimal variations of the controlled variable and responds instantaneously in accordance with its predetermined action.

501 *Positioning Action* is that in which there is a predetermined relation between value of the controlled variable and position of a final control element.

501*a* *Two-Position Action* is that in which a final control element is moved from one of two fixed positions to the other. ("Open and shut action," and "on-off action" are synonymous terms.)

501*aa* *Two-Position Differential-Gap Action* is that in which a final control element is moved from one of two fixed positions to the other when the controlled variable reaches a predetermined value from one direction, and subsequently is moved to the other position only after the variable has passed in the opposite direction through a range of values to a second predetermined value.

501*ab* *Two-Position Single-Point Action* is that in which a final control element is moved from one of two fixed positions to the other at a single value of controlled variable.

The differential gap of this type of two-position action is zero. Such controller action may also be considered as proportional-position action in which the proportional band is zero, or floating action with zero neutral zone and with infinite floating speed.

501*b* *Multiposition Action* is that in which a final control element is moved to one of three or more predetermined positions, each corresponding to a definite range of values of the controlled variable.

501*c* *Proportional-Position Action* is that in which there is a continuous linear relation between value of the controlled variable and position of a final control element.

501*d* *Average-Position Action* is that in which there is a predetermined relation between value of the controlled variable and the time-average position of a final control element which is moved periodically from one of two fixed positions to the other.

This controller action is similar to two-position action in which the percentage "time on" of the final control element is dependent upon the value of the controlled variable. The percentage "time on" may have either a fixed or infinite number of values to correspond to any one of the other positioning-controller actions defined previously.

502 *Integral Action* is that in which there is a predetermined relation between an integral function of the controlled variable and position of a final control element.

502*a* *Floating Action* is that in which there is a predetermined relation between value of the controlled variable and rate of motion of a final control element.

A neutral zone, in which no motion of the final control element occurs, is often employed in floating-controller action.

502*aa* *Single-Speed Floating Action* is that in which a final control element is moved at a single rate.

502*ab* *Multispeed Floating Action* is that in which a final control element is moved at two or more rates, each corresponding to a definite range of values of the controlled variable.

502*ac* *Proportional-Speed Floating Action* is that in which there is a continuous linear relation between value of the controlled variable and rate of motion of a final control element.

502*ad* *Floating Average-Position Action* is that in which there is a predetermined relation between value of the controlled variable and rate of change of the time-average position of a final control element which is moved periodically from one of two fixed positions to the other.

This controller action is similar to two-position action in which the percentage "time on" of the final control element is gradually changed at a rate dependent upon the value of the controlled variable. The rate of change of the percentage "time on" may have either a fixed or infinite number of values to correspond to any one of the other floating controller actions defined previously.

503 *Derivative Action* is that in which there is a predetermined relation between a derivative function of the controlled variable and position of a final control element.

503*a* *Rate Action* is that in which there is a continuous linear relation between rate of change of the controlled variable and position of a final control element.

This controller action maintains a linear relation between first derivative or rate of change of the controlled variable and position of a final control element. This identical controller action may also be considered as maintaining a linear relation between second derivative or rate of the rate of change of the controlled variable and rate of motion of the final control element.

504 *Multiple Action* is that in which two or more controller actions are combined.

504*a* *Proportional Plus Floating Action* is that in which proportional-position action and floating action are combined.

504*aa* *Proportional Plus Reset Action* is that in which proportional-position action and proportional-speed floating action are combined.

504*b* *Proportional Plus Derivative Action* is that in which proportional-position action and derivative action are combined.

504*c* *Proportional Plus Floating Plus Derivative Action* is that in which proportional-position action, proportional-speed floating action, and derivative action are combined.

504*ca* *Proportional Plus Reset Plus Rate Action* is that in which proportional-position action, proportional-speed floating action, and rate action are combined.

600 ADJUSTMENTS OF AUTOMATIC-CONTROLLER ACTION

601 *Neutral Zone* is a predetermined range of values of the controlled variable in which no corrective action occurs.

Neutral zone is commonly expressed in per cent of controller-scale range. A neutral zone is employed in some types of floating controller action.

602 *Differential Gap*, applying to two-position controller action, is the smallest range of values through which the controlled variable must pass in order to move the final control element in succession to both of its fixed positions.

Differential gap is commonly expressed in per cent of controller-scale range.

603 *Proportional Band*, applying to proportional-position controller action, is the range of values of the controlled variable which corresponds to the full operating range of the final control element.

Proportional band is commonly expressed in per cent of controller-scale range or, particularly in the absence of a controller scale, in units of the controlled variable.

604 *Floating Speed*, applying to single or multispeed floating controller action, is the rate of motion of the final control element.

Floating speed is commonly expressed in per cent of full-range motion per minute.

605 *Floating Rate*, applying to proportional-speed floating controller action, is the rate of motion of the final control element corresponding to a specified deviation.

Floating rate is commonly expressed in per cent of full-range motion per minute per per cent deviation.

606 *Reset Rate*, applying to proportional plus reset controller action and proportional plus reset plus rate controller action, is the number of times per minute that the effect of the proportional-position action upon the final control element is repeated by the proportional-speed floating action.

Reset rate is commonly expressed as a number of "repeats" per minute. It is determined by dividing (1) the travel of the final control element in 1 min due to the effect of proportional-speed floating action by (2) the travel due to the effect of proportional-position action, with the same deviation in both cases.

In automatic controllers having proportional plus reset action and a reset-rate adjustment, the proportional-band adjustment simultaneously affects the proportional-speed floating action in such a manner that the reset rate remains substantially constant at its set value.

Similarly, in automatic controllers having proportional plus reset plus rate action and a reset-rate adjustment, the proportional band may be adjusted without affecting the set value of the reset rate.

607 *Rate Time*, applying to proportional plus rate controller action and proportional plus reset plus rate controller action, is the time interval by which the rate action advances the effect of the proportional-position action upon the final control element.

Rate time is commonly expressed in minutes. It is determined by subtracting (1) the time required for a selected motion of the final control element, due to the combined effect of proportional-position plus rate actions, from (2) the time required for the same motion due to the effect of proportional-position action alone, with the same rate of change of the controlled variable in both cases.

In automatic controllers having proportional plus rate action and a rate-time adjustment, the proportional-band adjustment simultaneously affects the rate action in such a manner that the rate time remains substantially constant at its set value.

Similarly, in automatic controllers having proportional plus reset plus rate action and a rate-time adjustment, the proportional band may be adjusted without affecting the set value of the rate time.

700 ELEMENTS AND CHARACTERISTICS OF AUTOMATIC CONTROLLERS

701 The *Measuring Means* consists of those elements of an automatic controller which are involved in ascertaining and communicating to the controlling means either the value of the controlled variable, the error, or the deviation.

701*a* The *Primary Element* is that portion of the measuring means which first either utilizes or transforms energy from the controlled medium to produce an effect in response to change in the value of the controlled variable. The effect produced by the primary element may be a change of pressure, force, position, electrical potential, or resistance.

701*b* A *Self-Operated Measuring Means* is one in which all the energy necessary to actuate the controlling means of an automatic controller is derived from the controlled medium through the primary element.

701*c* A *Relay-Operated Measuring Means* is one in which the energy transmitted through the primary element is either supplemented or amplified for actuating the controlling means of an automatic controller by employing additional energy.

702 The *Controlling Means* consists of those elements of an automatic controller which are involved in producing a corrective action.

702*a* A *Power Unit* is a portion of the controlling means which applies power for operating the final control element.

702*b* The *Final Control Element* is that portion of the controlling means which directly changes the value of the manipulated variable.

702*c* A *Self-Operated Controlling Means* is one in which all the energy necessary to operate the final control element is derived from the measuring means.

702*d* A *Relay-Operated Controlling Means* is one in which the energy transmitted from the measuring means is either supplemented or amplified for operating the final control element by employing additional energy.

Index of Nonstandard Terms

Recognizing that many terms now in use are not found in the list of standard terms, the committee has included this section for the convenience of those who wish to become acquainted with the proper terms. It is hoped that the standard term will be used in place of a nonstandard term.

These cross-references are inexact, however, since different meanings exist for the same term, as well as different nonstandard terms for the same meaning. Many nonstandard terms may still be used properly to express meanings which are not covered by standard terms or not in conflict with the latter.

Nonstandard Terms	*Standard Term*
Anticipatory control	Rate action
Automatic reset	Proportional-speed floating action
Booster response	Rate action
Control band	Proportional band
Control effect	Corrective action

Nonstandard Terms	*Standard Term*
Control-index setting	Set point
Control instrument	Automatic controller
Controller function	Corrective action
Controller response	Corrective action
Control-point setting	Set point
Control response	Corrective action
Control setting	Set point
Conversion response	Proportional-position action
Corresponding control	Positioning action
Damping control	Rate action
Dead neutral	Neutral zone
Dead-period lag	Dead time
Dead spot	Differential gap or neutral zone
Dead zone	Differential gap or neutral zone
Deflection	Deviation
Delay	Dead time
Departure	Deviation
Desired condition	Desired value
Differentiating control	Rate action
Direct-operated controller	Self-operated controller
Displacement	Deviation and offset
Distance-velocity lag	Dead time
Drift	Offset
Drift compensation	Proportional-speed floating action
Droop	Offset
Droop correction	Proportional-speed floating action
Elastic follow-up	Floating action
Finite time lag	Dead time
Floating component	Floating action
Floating response	Floating action
Floating sensitivity	Floating rate
Floating time	Reset rate
Flow-lag	Dead time
High-low control	Two-position control
Hunting	Cycling
Inactive neutral	Differential gap
Index setting	Set point
Integral of deviation	Integral action
Integrating control	Integral action
Interval	Dead time
Inverse minutes	Reset rate
Kicker	Rate action
Lapse	Dead time
Load error	Offset
Loss of control point	Offset
Measuring element	Measuring means and primary element
Modulating control	Proportional-position action
Noncorresponding	Floating action
Normal	Desired value
On-off action	Two-position action
Open and shut action	Two-position action
Oscillating	Cycling
Overshooting	Cycling
Per-rate response	Rate action
Per-time response	Floating action
Pilot-operated controller	Relay-operated controller
Rate-component control	Rate action
Rate-of-change method	Rate action
Rate-of-departure component	Rate action
Rate of droop correction	Reset rate
Rate response	Rate action
Regulation	Offset
Regulator controller	Automatic controller
Reset constant	Reset rate

Nonstandard Terms	*Standard Term*
Reset control	Proportional-speed floating action
Reset response	Proportional-speed floating action
Reset sensitivity	Reset rate
Reset speed	Reset rate
Reset time	Reset rate
Response characteristic	Corrective action
Response delay	Dead time
Second derivative	Rate action
Self-acting controller	Self-operated controller
Self-actuated controller	Self-operated controller
Sensing element	Primary element
Sensitive element	Primary element and measuring means
Sensitivity	Proportional band
Servo	Power unit
Servo-operated controller	Relay-operated controller
Setting	Set point
Set value	Set point
Speed of reset	Reset rate
Swinging	Cycling
Throttling action	Proportional-position action
Throttling band	Proportional band
Throttling range	Proportional band
Time response	Rate action
Transportation lag	Dead time
Variable-speed reset	Proportional-speed floating action
Velocity-distance lag	Dead time

Engineering Evolution From War to a Peacetime World

(Continued from page 106)

dom of the scientist. Those occupied with pure research should suffer even less restriction than the applied scientist who must necessarily direct his efforts toward more practical and immediate objectives. But even he must be allowed opportunity for expression of his possible creative abilities.

In all our talk and love of freedom, however, the quality of individual responsibility inherent in it should not be overlooked. One must be prepared for this responsibility—he must have a prepared mind for his work—an alertness to the scientific problems and possibilities of his day. Thus the thought that should be left with students everywhere is the value of preparedness to justify our great heritage of democratic procedure. One of the richest assets which any graduate can take with him when he leaves college is the well-established habit of "doing a day's work in a day," of meeting his obligations on time, and appreciating that, whatever is genuinely gained and held to be truly worth while, is attained through a day-by-day best and willing endeavor. True success is merited and not found by accident. This means preparation and constant training, with the student making every day count toward the best of which he is capable.

Today is a time when intelligence, courage, and sustained effort, together with discipline, are indispensable. In the classrooms and laboratories, one learns to school himself to a self-imposed regimen of discipline in study and thought. He does this willingly, knowing that failure to do so will leave him by the wayside. These are habits which attend the truly successful engineer throughout his life.

ENERGY *Losses in* *the* CHAIN-BELT *Problem*

By F. R. ARCHIBALD

EXPERIMENTAL ENGINEER, BROWN & SHARPE MANUFACTURING COMPANY, PROVIDENCE, R. I.

An energy solution to the dynamics of chain action is to be presented which, to the author's knowledge, is a new approach to this problem.

If a catalogue of any chain manufacturer is examined, it will be found that the rated speeds of chains vary inversely with the pitch. Thus chains of the lowest pitch run at the highest speed and vice versa. The reason for this is not altogether self-evident. It is, however, a fact that chain action is not a smooth process but is accompanied by impacts as each link engages a sprocket. These impacts can reach destructive intensity if rotational speeds are high enough. As the impact increases with the size and mass of the chain links, it is seen that a top limit of rotational speed exists for each size of chain.

It must be pointed out here, though, that chain-speed ratings from manufacturers are properly conservative. If recommended practice is followed, chains provide one of the most trouble-free of power-transmitting methods.

CONVENTIONAL IMPACT ANALYSIS

The impact problem, however, does exist and, as has been pointed out, imposes a speed limitation on chains. A conventional impact analysis, which is quite well known, has been developed and has been used as a guide in chain engineering. Although this conventional method has no part in the solution to be presented later, it will be reviewed for the sake of completeness.

Fig. 1 is a diagram for demonstrating the conventional analysis of chain action. From it the following relations are clear:

Relative velocity of link and sprocket at impact

$$= 2R\omega \sin \theta$$

But

$$\sin \theta = \frac{{}^1\!/_2 P}{R} = \frac{P}{2R}$$

$$\therefore \text{ Impact velocity } = 2R\omega \times \frac{P}{2R}$$

$$= P\omega$$

$$\therefore \text{ Loss at each impact } = \frac{1}{2} MP^2\omega^2$$

Chain speed $= R\omega$

$$\therefore \text{ Number of impacts per sec } = \frac{R\omega}{P}$$

$$\therefore \text{ Loss per sec } = \frac{R\omega}{P} \times \frac{1}{2} MP^2\omega^2$$

$$= \frac{1}{2} RMP\omega^3$$

$$\therefore \text{ Horsepower loss } = \frac{RMP\omega^3}{1100}$$

where M is the mass of a link.

The foregoing analysis shows the impact to be proportional to the product of the mass of a link and the square of the pitch. Since the mass of a link is usually considerably increased with the pitch, the obvious conclusion is that for high speeds chains of low pitch should be used.

The foregoing relations are the basic ones in the conventional impact analysis and have been widely used in chain engineering. This method has behind it the weight of its long standing and a certain plausibility. It has, however, at least four questionable factors associated with it.

These are as follows:

1 If the velocity diagram is examined, it will be seen that, in order for the relative velocity shown to occur, links down

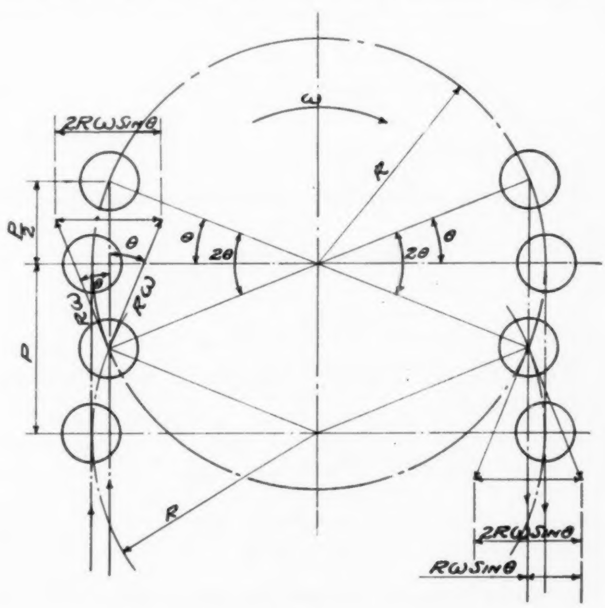

FIG. 1

in the straight portion of the chain must take part in the side movement. It is difficult to say how many links would be involved and how their mass will affect the impact.

2 The trailing end of the link is shown curving in during engagement. When it is considered that centrifugal force is now acting on this link its tendency to curve in must be seriously doubted.

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3 To return again to the velocity diagram, Fig. 1, if the action is as shown on the approach side of the sprocket, it must be presumed to be the same on the leaving side. Here, however, the relative velocity would be one of separation rather than impact. But it will be noted that one half this velocity of separation, viz., $R\omega \sin\theta$, is a horizontal velocity of the chain. This implies a kinetic energy in the chain on leaving the sprocket which must be lost to heat. This can be expressed as a further horsepower loss.

4 Perhaps the most concrete objection to the conventional method is that, if the horsepower loss is computed by it, the results are in excess of measured values, and no allowance has been made for joint friction. The loss shown in item (3) would only serve to make matters worse.

A NEW APPROACH TO THE PROBLEM OF CHAIN LOSSES

The problem of chain losses will now be considered from another point of view. As a preliminary, a standard piece of work in mechanics must be given in order to deduce a formula for a special case.

If a mass M_1, Fig. 2, traveling at velocity V collides with a

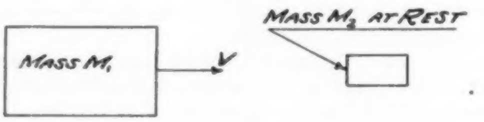

FIG. 2

mass M_2 at rest and they attain a common velocity, the following relations can be written

$$\text{KE before impact} = \frac{1}{2} M_1 V^2 \quad \text{[1]}$$

$$\text{KE after impact} = \frac{1}{2}(M_1 + M_2)v^2 \quad \text{[2]}$$

where v is the common velocity attained by both bodies.

Further

Momentum before impact = momentum after impact

or

$$M_1 V = (M_1 + M_2)v$$

$$\therefore\ v = \frac{M_1}{M_1 + M_2} V$$

If this value of v is placed in Equation [2], the KE after impact is given by

$$\frac{1}{2}(M_1 + M_2) \times \frac{M_1^2}{(M_1 + M_2)^2} V^2$$

$$= \frac{1}{2} \frac{M_1^2}{M_1 + M_2} V^2 \quad \text{[3]}$$

A loss of energy of motion takes place. This loss is obviously the difference between Equations [1] and [3]

$$\text{Loss} = \frac{1}{2} M_1 V^2 - \frac{1}{2} \frac{M_1^2}{M_1 + M_2} V^2$$

$$= \frac{M_1 V^2 (M_1 + M_2) - M_1^2 V^2}{2(M_1 + M_2)}$$

$$= \frac{1}{2} \frac{M_1 M_2}{M_1 + M_2} V^2$$

If numerator and denominator are divided by M_1 the loss becomes

$$\frac{1}{2} \frac{M_2}{1 + \dfrac{M_2}{M_1}} V^2$$

It is clear that if M_1 is very large (infinite), the fraction $\frac{M_2}{M_1}$ approaches zero, and the loss has the value $^1/_2 M_2 V^2$.

To recapitulate: If an impact occurs between a large body M_1 with a velocity V and a relatively small body M_2 at rest, there is a loss of energy at impact equal to $^1/_2 M_2 V^2$. It must be noted in addition that the small body gains energy equal to $^1/_2 M_2 V^2$, i.e., the total output of energy from mass M_1 is $M_2 V^2$, one half of which is lost (as heat or it could be stored elastically), and one half of which is gained by M_2 as kinetic energy.

This, as will be observed, is a well-known principle in mechanics. The equally fundamental and parallel proposition is that, in rigid dynamics, the loss can be shown in just the same way to be $^1/_2 I_2 \omega^2$, where I_2 is the moment of inertia of the small body and ω is the rotational speed of impact in radians per sec. It is with this latter, rotational, quantity that we are here concerned.

With the foregoing demonstration of a clutching loss in mind, the chain problem will now be examined from an energy point of view.

Consider a link on the sprocket, Fig. 3. Because it has a

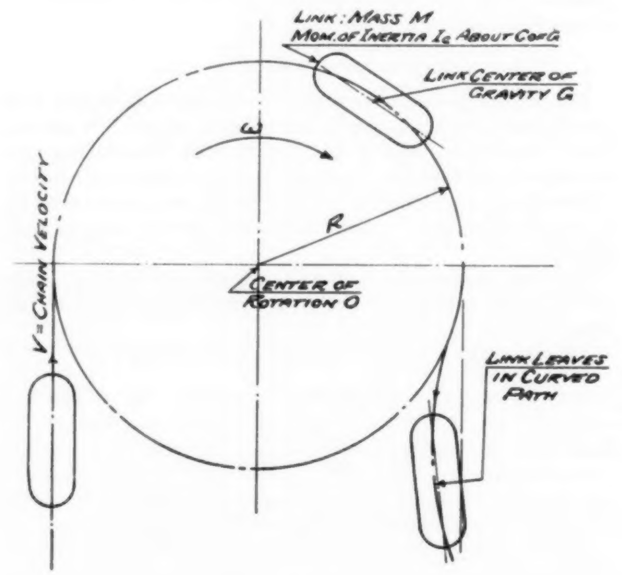

FIG. 3

rotation about the sprocket center O it has KE of rotation

$$\text{KE} = \frac{1}{2} I_o \omega^2 \quad \text{[4]}$$

Where I_o is the moment of inertia of the link about rotation center O.

Now

$$I_o = I_G + MR^2 \quad \text{[5]}$$

(R is practically the sprocket radius)

If I_o from Equation [5] is placed in Equation [4], the KE of rotation of the link is

$$\frac{1}{2}(I_G + MR^2)\omega^2$$

$$= \frac{1}{2}I_G\omega^2 + \frac{1}{2}MR^2\omega^2$$

$$= \frac{1}{2}I_G\omega^2 + \frac{1}{2}MV^2$$

The last term here, viz., $^1/_2\, MV^2$, is obviously the KE due to the linear velocity of the link and must be always with it. The term $^1/_2\, I_G\omega^2$, however, exists only when the link is on the sprocket. This KE of rotation must be eliminated before the chain can straighten out. It is eliminated by flexing of the chain as it leaves the sprocket. This gives the familiar kink on the leaving side of a sprocket. If the chain is very loose more than one kink can be seen, and a kind of damped wave runs along the chain.

So far in this analysis only a loss of energy has been shown. This loss occurs through friction at the chain joints and does not cause impact loading. It is now necessary to consider the chain on the approach side of the sprocket.

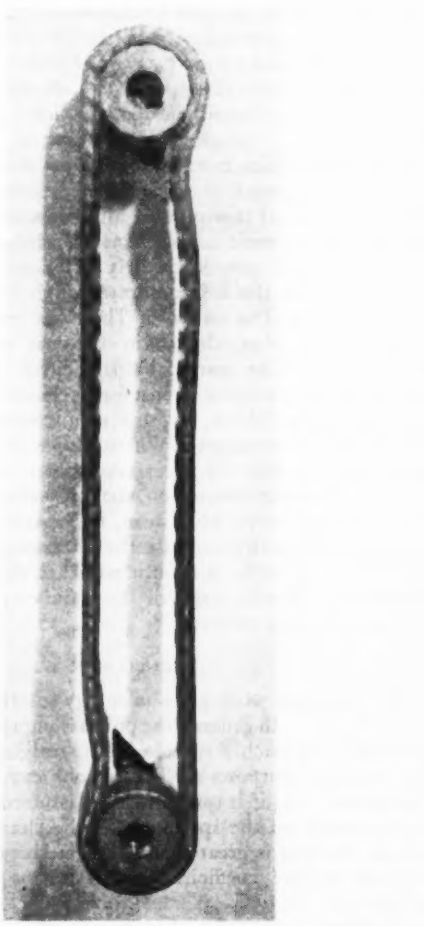

FIG. 4 $^1/_2$ IN. PITCH SILENT CHAIN ON TWO 3-IN. SPROCKETS TURNING AT 1800 RPM

Before a link reaches a sprocket it is proceeding in a straight line with KE of translation only. Suddenly it engages the sprocket where it obtains KE of rotation in addition. This is a "clutching action," i.e., a rotational impact occurs. It must therefore be accompanied by a loss of energy equal to the gain in the energy of the link, as was shown in the beginning. It is clear then, that when a link goes on a sprocket a loss of energy equal to $^1/_2\, I_G\omega^2$ must occur.

This loss occurs through a blow or blows because there can be no significant flexing of the chain after it gets on the sprocket. This blow can produce destructive stresses in the link if the rotational speeds are high enough.

A BASIC PRINCIPLE OF BELT ACTION

The foregoing work is a basic principle involved in all belt action. It can be used to calculate impact loads on the so-called silent chains, although the moments of inertia of the links would be difficult to calculate accurately. They might be obtained experimentally on large laminar models by a pendulum method. In the case of a belt, the wrapped portion on the pulley has a moment of inertia about the pulley center. Thus the KE of rotation of this part is greater than the KE of translation of the straight parts off the pulley.

The same losses are involved here as in chains, although the author has never seen a belt kinking on leaving a pulley. There must also be a blow on the entrance side, and this probably means that there is a tendency for the belt to pucker in going on the pulley, although this too has not been observed by the author. These effects in belts are small because of the low density of the material and because of the relatively small thickness of belts compared to pulley diameters. In so far as belts are concerned, the effect is probably without much practical significance. It can readily be computed as a horsepower loss. The total horsepower loss for a pulley, which includes going-on and leaving losses, is given by

$$\frac{\rho l t^3}{2200\, g}\left(R + \frac{t}{2}\right)\omega^3$$

where

ρ = belt material density, lb per cu ft
l = belt width, ft
t = belt thickness, ft
R = pulley radius, ft
ω = pulley speed, radians per sec
g = gravity constant

This factor could be used in calculating belt-drive efficiencies, but the figures obtained by it are very small. Belt-flexing losses are probably of far greater importance.

It may be objected that the foregoing work has been done with no reference to the fact that in any real case impacts are not perfectly inelastic. The reason for omitting this from the work is for the sake of clarity and brevity. The whole problem can be worked considering the impact to be imperfectly elastic, but it adds complication and calls for more algebra.

However, it is not sufficient merely to state that elasticity can be neglected. Actually, this is not so in the general case.

This will not be taken up in full detail as it is not of sufficient importance to the main result. Any reader, sufficiently interested, can readily consider the matter fully. Further, in a paper of this kind it is impossible to cover all the implications of a subject.

It can be shown that if the impact of the illustration, Fig. 2, is imperfectly elastic, the mass M_2 will proceed, after impact, with a velocity

$$v = (1 + \epsilon) \frac{M_1}{M_1 + M_2} V \ldots\ldots\ldots\ldots [6]$$

where ϵ is the coefficient of restitution between the bodies.

This means that the mass M_2 will gain from the impact a kinetic energy

$$KE = \frac{1}{2} M_2 (1 + \epsilon)^2 \left(\frac{M_1}{M_1 + M_2}\right)^2 V^2 \ldots\ldots [7]$$

at the expense of M_1.

A loss of energy to heat also occurs at impact. This loss has the value

$$\frac{1}{2} \frac{M_1 M_2}{M_1 + M_2} (1 - \epsilon^2) V^2 \ldots\ldots\ldots\ldots [8]$$

Both Equations [7] and [8] have been supplied by part of the KE of M_1.

Again if M_1 is large compared to M_2, Equation [7] becomes

$$KE = \frac{1}{2} (1 + \epsilon)^2 M_2 V^2 \ldots\ldots\ldots\ldots [9]$$

If ϵ is zero, i.e., inelastic impact, the KE gained is again $^1/_2\, M_2V^2$, and also the loss which is shown in Equation [8] becomes $^1/_2\, M_2V^2$ (again assuming M_1 is large). This is the result originally shown.

The work, as before, has been done in linear mechanics because it is more familiar, and perhaps mental pictures of the process are easier to form. The whole thing can just as easily be done in rotational mechanics and, as before, the equations are of the same form. Thus for the link and sprocket, Equation [9] becomes

$$KE = \frac{1}{2} (1 + e)^2 I\omega^2 \ldots\ldots\ldots\ldots [10]$$

This represents the gain in kinetic energy given a link after its first blow. If, as in the case of a link on a sprocket, the two bodies cannot escape from each other but must finally come to a condition of relative rest, the whole process can be regarded as an inelastic impact. This follows from the principle of impact, viz., that there has been no net change of momentum.

However, it is conceivable that a chain might go around a sprocket with such a small angle of wrap that the links would not have time to become seated. They might only receive one blow. They would then escape into the straight part of the strand with considerably more energy than they would normally leave a sprocket. This might give rise to considerable vibration in the straight strand. It would also increase the power loss.

It should be noted, however, that in so far as the impact stress is concerned there has been no change. At the first impact, elastic energy was stored equal to $^1/_2\, I\omega^2$, and this is always the same regardless of what happens afterward, at least in so far as this analysis can show.

CONSIDERATION OF ROLLER-CHAIN PROBLEM

To return to the roller-chain problem—a point of some small importance is the matter of the free roll. If this roll were frictionless on its pin, it would only enter the moment of inertia of the link by the amount $\frac{mP^2}{4}$, where m is the mass of the roll, and P is the pitch of the chain. Its I_G would not be added to the I_G of the link. It would be clutched up to speed, i.e., rotational speed about its own center of gravity, by the friction of the sprocket on its outside diameter, and this loss would not be chargeable to the impact. It would only cause an energy loss to heat, and hence a horsepower loss. There is some uncertainty about this matter, however, and perhaps experiment is necessary to determine how this small quantity should be handled.

The following experiment can be made: Remove a link from a chain with free rolls on it. Drill a hole through the link at the center of gravity (of the link). Then mount the link on a loose-fitting spindle through this hole and hold this spindle in a collet of a high-speed lathe. The link will come up to lathe spindle speed because of the slight friction drag. If the link is then suddenly stopped, the rolls can be watched for rotation.

The author has done this with a small link but no rotation was observed. The deceleration force on these rolls, in stopping their rotation about the center of gravity of the link, sets up high side pressure and hence high frictional drag on the pin. Evidently this friction force is sufficient to absorb all of the energy of the roll, due to its rotation about its own center of gravity, in friction work. If it can be assumed that the frictional drags on these rolls, in all sizes of chains, are sufficient to leave the roll stationary after the link has been decelerated from sprocket speed, it can also be assumed that the roll is acting as a rigid part of the link. Its I_G must therefore be added to the link's I_G. On a sprocket there is in addition considerable centrifugal force. This further increases pin pressure.

A question which must arise is: How do blows occur when links go on a sprocket? A complete answer may not be possible. The actual motion of a link depends on a number of more or less uncertain factors. All that has been shown is that a loss of energy must occur. It is merely inferred from the conditions that the loss occurs through blows. The action has been pictured as follows: The links resist being forced to rotate. Thus after the chain becomes tangent, a turning moment has to be exerted by the chain. In doing so the loss energy is stored for an instant in chain stretch. The links are then snapped back, by this spring action, into the teeth and the first blow occurs. Whether there are further blows depends on a number of uncertain factors, such as chain tension, coefficient of restitution, damping effect of the lubricant, etc. Evidently these blows can, under sufficiently high rotational speed conditions, raise the stress to a value that is destructive. Actually, it is only necessary that the roll stress be raised to a value in excess of the endurance limit for eventual failure by fatigue to occur.

CONCLUSION

The foregoing work gives an energy solution to the matter of chain impact. In general, the only assumption necessary is that the chain approach a sprocket in a straight line (or nearly so for practical purposes). The impact can be expressed as a horsepower loss if it can be further assumed that the chain becomes seated on the sprocket. If the chain does not become seated, the loss is greater but its value is not predictable as it depends on the coefficient of restitution between link and sprocket.

Needless to say there are many other problems of chain action and even in the matter under consideration a complete analysis of the dynamics of a link has by no means been given. It is interesting, however, that in this complex matter an important quantity can be calculated by such a simple method.

ALICE *and the* SLUGGERS[1]

By L. A. HAWKINS[2] and SANFORD A. MOSS[3]

ALICE was sleepy. She was tired from pushing a slide rule all day, making calculations on a strange thing called jet propulsion. Her profession—a new one for girls—was making engineering computations.

But Alice was sleepy. Her thoughts of slide rules and figures seemed to blur and become meaningless; and they escaped from their difficult task and fled, as they often did, across the Atlantic to her happy childhood home in England. She liked her name, Alice, for, as far back as she could remember, her favorite heroine had been that other Alice who had those marvelous *Adventures in Wonderland* and *Through the Looking Glass*. She had liked to think of herself as Alice, Jr. Later, at Oxford, her studies of mathematics and physics gained extra zest from the thought that she was following directly in the footsteps of the master, Lewis Carroll, whose whimsical brain had given birth to her heroine. Then she had been projected across the ocean to apply her mathematics to the feverish war work of Britain's great American ally.

But now it was not to an England torn by bombs that her sleepy thoughts turned, but to a peaceful England where whimsies of white rabbits led little girls to confusing but delightful adventure. Suddenly her wandering mind was recalled to her room, which had become strange. Beside her sat a man whom she dimly recognized as her engineering supervisor, but whose huge hat and deintellectualized features revealed him clearly as the Mad Hatter himself.

"Alice, Jr.," began the Mad Hatter, "your work is seriously defective. You should make that computation in slugs."

"But," said Alice, Jr., "a slug is a slimy thing like a snail, that eats cabbages."

"Well," said the Mad Hatter, "some people say this kind of a slug is slimy all right, but it isn't like a snail. It is what you get (if you use pounds-force, feet, and seconds) when you divide weight by gravitational acceleration. This is W divided by g and tells how much mass you have. I suppose we could define mass with any units of force and length, but most people use pounds-force and feet and seconds and get slugs."

"We never learned that in England," said Alice. "We learned that mass was the muchness of anything, like how much sugar you get for sixpence and a ration stamp, and often we called it 'weight' instead of mass. I think of muchness as meaning quantity of matter, which is the same, or nearly the same, as inertial mass. And when you say 'gravitational acceleration,' I suppose you intend to include the very tiny centrifugal force due to the earth's rotation, and really mean net acceleration."

"Yes, of course," said the Mad Hatter, "if you want to be particular. But your first statement was wrong; weight is not mass, but is gravitational force on a mass."

"Well," said Alice, Jr., "you can tell the muchness or mass of anything by weighing it on beam scales against standard chunks of mass that even you call 'weights.' When my mother wants to see if she is getting too fat, she does this and she calls it her weight. I am sure it tells her how much is inside of her, and has nothing to do with the actual value of gravitational force. Besides, a groceryman who lives high up in Mexico City, not far from the equator, or who lives in Canada near sea level, or even grocerymen on the moon, if there are any, will sell the same muchness and sweetness for a pound of sugar, by weighing it against the same 'weights' on a beam scales, and I know the gravitational force that you want to call weight is quite different in these different places. So what you call the weight of a 'weight' doesn't tell you much of anything. But you can tell the mass in pounds just by looking at the numbers stamped on the weights, without the extra bother of thinking about force and acceleration and what you call weight."

"Well," snapped the Mad Hatter, "when you weigh a thing against weights, you can't call the muchness weight, you have to call it mass."

"All right," said Alice, "I won't say weight any more, but will say mass instead. But lots of people don't know that you call gravitational force 'weight,' and they think weight means mass. So you'd better stop using your ambiguous word 'weight,' and say 'gravitational force' instead. But what has that got to do with slugs? I'm always used to measuring mass in pounds, as I've said already."

"No," said the Mad Hatter, "you've got to think about slugs. A pound is just like a slug, but is about a thirty-twoth of it."

"Now you're getting us all mixed up," said Alice, Jr. "Even if we are going to use the word 'mass' instead of 'weight' for muchness, when my grocer has a pound-weight on one side of a beam scales or balance, and some sugar on the other side, and they balance, why can't we call it a pound of sugar? Then we don't even need to mention weight or slugs or W/g. Besides, the OPA doesn't have any ration stamps for slugs of sugar."

"I keep telling you," said the Mad Hatter, "you've got to measure muchness in slugs."

"I don't know why," said Alice. "You can't say that W/g in slugs is the only unit for mass. Chemists in England and America measure muchness in pounds, which I am willing to say is the pound-mass instead of the pound-weight. Mechanical-engineering handbooks talk about 480 pounds of iron in a cubic foot, and so many pounds of wire per 100 linear feet and all that. Industry and commerce in the United States and Great Britain really are based on the pound-mass. The chemist's pound-molecule is based on the pound-mass. Whoever heard of a slug-molecule? The international standard of mass isn't a slug; it's the International Prototype Kilogram, and there is a copy of it in the National Bureau of Standards. The standard pound-mass is defined by United States law as a specified fraction of the kilogram, and a representation of this also is kept by the Bureau of Standards.

"Then any pound-mass is what balances a replica of this chunk of muchness called the standard pound-mass, on a beam balance, anywhere, at any altitude, on earth or moon. It has been proved once for all that this gives inertial mass, so we don't have to stop and confuse ourselves every time we use a beam balance, or write an equation; by supposing that we are measuring gravitational force, or what you call weight; or by slugs. A standard pound-force is how much this pound-mass is pulled at any place where there is the International standard value of gravitational acceleration, 32.1740 ft/sec^2.

[1] Published through the courtesy of the *American Journal of Physics*.

[2] Consulting Engineer, Research Laboratory, General Electric Company.

[3] Consulting Engineer, Aircraft Gas Turbine Engineering Division, General Electric Company. Fellow A.S.M.E.

"Everybody was happy when we used to talk about poundals, and then force in poundals was mass in pounds times acceleration, or $F = ma$. But if we want to use the pound-force, which is about 32 times as big as a poundal, we can keep the pound-mass that is used in everyday life, and put a pure number—about 32—in the denominator because the force unit has a numerical value which is about $^1/_{32}$ of the value in poundals. We may define this denominator as a pure number, equal to g_0, the absolute value of the International standard value of g, and use it in the equation $F = \frac{m}{g} a$, without any complications about gravitational forces or slugs. Some precise people call this g_c. We have exactly the same numbers to work with and the same arithmetic as you do with slugs and the equation $F = \frac{W}{g} a$, without the fogginess of this new and highbrow slug, and as I said before, without having to decide whether W and g are standard or local values and without thought of weight. Frenchmen do the same thing with the kilogram-force and kilogram-mass. Nobody wants to think of a metric slug."

"Well," said the Mad Hatter, "if you are going to work with the aerodynamics people, I keep telling you that you can't measure mass in pounds any more, and have got to measure it as some of them do, as the quotient of gravitational force and gravitational acceleration."

"That sounds like jabberwocky to me," said Alice. "A pound-mass is a pound-mass, whether it is on the moon or anywhere. Do you know the gravitational acceleration on the moon? If you want to compute the forces and accelerations on an airplane at 60,000 ft, you can't say that the gravitational force and acceleration, which your W and g explicitly mean, are practically the same as at sea level."

"But the mass in slugs doesn't change with altitude," said the Mad Hatter, "because the weight and the gravitational acceleration change in the same ratio. And when we use in the equations W and g that explicitly mean actual values, we don't intend that at all, but do intend standard values, W_s and g_0."

"Then it's silly to use W and g," said Alice. "You put in their values that everybody knows are variable, and whose ratio in some units people call slugs, and then you say you don't need the actual values after all. So it's simpler to stick to the pound-mass and the standard pound-force that you know have the same value at all altitudes, instead of using W and g, both of which vary. Then you can use the actual value of gravitational acceleration at high altitudes when it is needed for computation of airplane accelerations.

"All the thermodynamics people that I know talk about a pound of working substance. If you keep on talking about slugs, I suppose next you will want to have me talk about entropy of a slug of steam."

"Why, of course," said the Mad Hatter, "Newton's second law says that force is equal to mass times acceleration, and the only way you can follow Newton is to measure mass in slugs, even with entropy."

"I was told that Newton's second law doesn't say anything of the kind," replied Alice, Jr., "but that he said—in Latin—that force was ***proportional*** to mass times accelerations. So in Newton's second law I can, as I said, measure force with the standard pound-force and muchness with the pound-mass, by putting in this proportionality factor with no dimensions, whose numerical value is that of the standard g. I still think that's a lot simpler than having to think that mass is gravitational force divided by g. Why, some of the people who do this are so ashamed of it that they won't even call it a slug, but just say it is a unit of mass. Other people add to the confusion by calling it a gee-pound. But I am going to stick to the good old pound as the unit of mass, just as the grocer does. There was a chunk called the standard pound, in England, maybe before the Pilgrims landed in America, and Sealers of Weights and Measures, and Bureau of Standards in both countries have equivalent chunks to this day. It is much simpler to think of mass as something measured by comparison with these standard chunks, than as being the quotient of W and g. And if you do this, you don't have to introduce your concept of weight at all in talking about mass.

"And as for entropy of a slug, entropy is hard enough to understand, anyway, without having to mix up slugs with it. All the steam tables and ammonia tables give entropy per pound of muchness. Who wants to have all the steam tables done over in slugs? So mechanical and chemical engineers now working on jet propulsion have all of their lives measured the working substance and the values of entropy, enthalpy, and heat of combustion, all in terms of the pound-mass as the unit, and so does Professor Keenan's new book on *Thermodynamics of Air*. The plane builders get the mass of the plane in pounds, and the pound-mass and standard pound-force are perfectly good units to keep on using when the thrust on the plane is being computed. The Wright Brothers and their successors who started building airplanes were mechanical engineers, and if other people want to come into this territory and make aero dynamic computations, they oughtn't to mix us up by trying to foist slugs on us. Students in colleges have been befuddled for years because machinists, grocerymen, and their professors of thermodynamics and chemistry use the pound-mass, while their professors of theoretical mechanics, who teach them in the next hour, use slugs."

"How does a girl computer like you come to know so much physics?" asked the Mad Hatter.

"Well," said Alice, "the talk about slugs and gee-pounds and three different kinds of weight and poundals and kilograms-force and dynes and pressure in bars was a Wonderland more mixed up than anything the other Alice ever got into, so I studied and found the only way out was to keep on with the good old-fashioned pound-mass."

"Well," said the Mad Hatter, "even if everybody once used the pound-mass and everyday people still use it, lots of people have learned slugs and have come to believe them best, and we have to please them."

"We must re-educate them," said Alice. "Lots of people once believed in caloric and the luminiferous ether and phlogiston and said 'force' where we now say 'energy,' and they re-educated themselves. Mass measured in slugs or as W/g is not essentially wrong like those things, but it has been part of many people's education. So the sluggers must realize that slugs do cause confusion, and that there is a point of view that uses the pound-mass as it is used in everyday life, and that many engineers use it with complete accuracy, with the 32.1740 in Newton's second law as a proportionality constant without dimensions. Then the sluggers may be willing to be re-educated.

"Anyway," continued Alice, Jr., "no slugger is going to befuddle me the way they do lots of college students with their slimy old slugs. I am willing to give up the word 'weight' and use the word 'mass' instead, but it's got to be the pound-mass. So, nuts to your slugs."

The Mad Hatter didn't seem convinced but he was so vexed that he had no answer and disappeared. Thoughts of slide rules and notebooks returned to Alice. But she was too confused and sleepy to do more work that night, so she was soon in bed, and, with the soporific melody of the Mock Turtle's song running through her head, fell fast asleep.

ORDNANCE SUPPLY SYSTEM

III—Ordnance Storage Techniques

By BRIG. GEN. E. E. MAC MORLAND, U.S.A.

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PREVIOUS sections of this paper, discussing the operation of Army Ordnance depots in this country, have described the depot problem as a whole, as well as methods used in daily scheduling of materials-handling operations. In this section are discussed general materials-handling principles, in their application both to ammunition and general-supply depots.

HANDLING AMMUNITION

Handling of ammunition is an explosives problem. The explosive hazards inherent in the commodity being stored influence every phase of the operation; how and where it is stored, the method of handling, the manner in which it is shipped.

Special Safeguards. The explosive characteristics of the material first suggest the special safeguards that are enforced to reduce probabilities of disaster. The rigidity with which these special safeguards have been enforced is, in part at least, accountable for the excellent safety record that has been built up by the ammunition depots during the present war, a record established with personnel who, almost without exception, had no previous experience in handling explosives and, accordingly, had to be carefully schooled and trained in the hazards of their new occupation. These safeguards have influenced storage and handling methods. They have created constant problems in the utilization of space and in the development of cost-saving handling methods.

First, definite limits exist on the quantity of explosives that may be stored at any one point. Quantity limitation considers the areas that would be affected by explosion of variable quantities of a given type of ammunition. In order to control the extent of damage and loss, quantity-distance tables, developed through many years of experience with actual explosions, have been established and are contained in the Ordnance Safety Manual. They govern the quantities of ammunition that may be stored in a given place. For example, when packed in accordance with Ordnance drawings and specifications, fixed and semifixed artillery ammunition (complete round) has a quantity storage limitation not to exceed 500,000 lb. The following distances from point of storage must be maintained:[1]

Inhabited building, distance	Public railway, distance	Public highway, distance	Magazine distance
1200 ft	1200 ft	1200 ft	300 ft

[1] Ordnance Safety Manual, May 3, 1945, p. 84.

This series of papers was planned and prepared under the direction of Colonel L. J. Meyns, Chief of the Storage Division, Field Service, Office, Chief of Ordnance, by Major Preston D. Carter, Assistant to the Chief of Storage Division, Field Service, Office, Chief of Ordnance. Major Carter was aided in the Section on Packaging by Mr. A. L. Whiton, Chief of the Packaging Branch, Industrial Service; in the Section on Scheduling Depot Operations by Major Ira A. Ruhl, Control Officer, Pueblo Ordnance Depot. The Section on Ordnance Storage Techniques was prepared by Major Warner H. Davis, Control Officer, Letterkenny Ordnance Depot and Major R. S. Craig, Administrative Officer, General Supply Division, Letterkenny Ordnance Depot.

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There is also a restriction on types of ammunition that may be stored together. All explosives and ammunition are stored by type, according to the special explosive characteristics determined through tests over a long period of time. Those types which must be completely segregated, as well as the types that can be stored with other kinds of ammunition, are clearly defined. Fragmentation bombs, as an example, can be stored only with the following types of ammunition:[2]

(*a*) Mines, armor-piercing.
(*b*) Mines, high-explosive antitank.
(*c*) Shell, heavy mortar (greater than 81 mm).
(*d*) Bombs, demolition.

The necessity for maintaining in storage the identification of production lots was discussed in the second section of this paper.

Effect of Safety Restrictions. Each of these restrictions has an important bearing on handling methods and the utilization of space. A vivid picture of contrasting space occupancy resulting from quantity limitations is given by a comparison between the storage of 4000-lb bombs and 155-mm shells. Because of the explosive limit of a 4000-lb bomb, only 77 bombs can be stored in a single igloo, while their shipment will require only three standard railroad cars. On the other hand, the same igloo will hold 15,000 155-mm shells and use 15 standard railroad cars for shipment. This condition must be considered in standard storage practice. Since the explosive limits on bombs usually limit the quantity in storage well below the potential cubic space accommodations, good practice dictates their storage in the smaller igloos where, unfortunately, less space is available for maneuvering materials-handling equipment.

Lot storage causes a complication in gaining access to a particular lot of ammunition. If several lots are stored in an igloo, it may be necessary to remove the first lot in order to reach a lot directed for shipment. The most effective solution developed to date, in those cases where it appears as though the lot size will be too small to fill an igloo, is to commence storage lengthwise of the floor, filling first one side of the center aisle, then the other, rather than from front to back. Thus, either lot may be removed without having to traverse the center aisle with a loaded fork-lift truck.

The limited dimensions of an igloo further complicate the storage of ammunition. The design of this type of storage magazine has been influenced by consideration of explosive hazard. The modern type concrete igloo is designed to direct the main force of any explosion mainly in an upward direction. The sides, thick at the bottom, curve inward to form a semicircular roof and taper to a thickness no greater than needed for structural strength; there is a door at one end only. This type of construction produces problems in materials handling that are not identified with the average type of storage warehouse. Special study has been necessary to accomplish stacking that would conform with the over-all outline of the curved inner walls of the igloo with adequate aisles to permit ready

[2] Loc. cit., p. 104A.

FIG. 13 ONE OF TWO METHODS FOR FORK-LIFT HANDLING OF SMALL-DIAMETER CYLINDRICAL ITEMS; 155-MM PROJECTILES, 8 PER PALLET, ARE UNITIZED FOR STORAGE AND SHIPMENT

inspection. Particular difficulty, for example, has been encountered in handling boxed ammunition so that sufficient boxes may be stored in pallet stacks that follow the contour of an arched roof.

The development and use of materials-handling equipment was discussed in a preceding section. To obtain proper maneuverability for this equipment, loading aprons have been constructed at the loading docks in many depots and the dimensions of the car-level concrete docks at the loading point modified. Fanlike, or L-shaped concrete forms have been added to the igloo platforms. This addition permits turning the fork-lift truck around before it enters the igloo, an important consideration in storing palletized ammunition in 60-ft igloos where, on one side, the last 15 ft of storage in depth must be accomplished by hand unless there is space for turning the lift outside the igloo.

Palletization. Handling-method characteristics are associated with two common categories of ammunition; cylindrical ammunition (such as bombs and separate loading shells) and boxed and crated ammunition. Because the latter type involves fewer explosive hazards and the containers more closely resemble general supply materiel, small-arms ammunition was the first to receive experimental study. As a result of comprehensive tests, palletization of boxed and crated ammunition, with few exceptions, has now become standard practice.

During the past 2 years it has been found practicable to palletize some types of cylindrical ammunition. Unit loads, Figs. 13 and 14, have recently been developed for separate-loading shells of all sizes and for small bombs. This ammunition is now shipped to the depot, stored, and reshipped to destination on pallets with a resultant economy in time and manpower all along the line.

Where shipping pallets have not yet been developed, items are palletized at the depot for storage only.

Initial efforts to store palletized ammunition resulted in a sizable loss in storage space at the depot because the size and rectangular shape of the pallet load complicated conformity to the curved lines of the igloo roof. The utilization of space within these dimensional limits was, in this case, a factor of importance, since the explosive limits of boxed and crated ammunition will generally permit storage of sufficient quantity to fill an igloo completely. Fig. 15 shows the manner in which

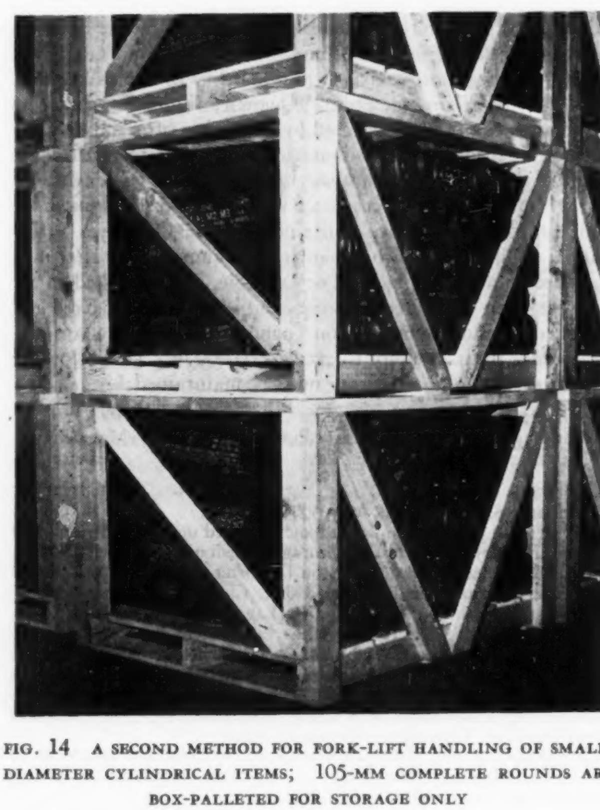

FIG. 14 A SECOND METHOD FOR FORK-LIFT HANDLING OF SMALL-DIAMETER CYLINDRICAL ITEMS; 105-MM COMPLETE ROUNDS ARE BOX-PALLETED FOR STORAGE ONLY

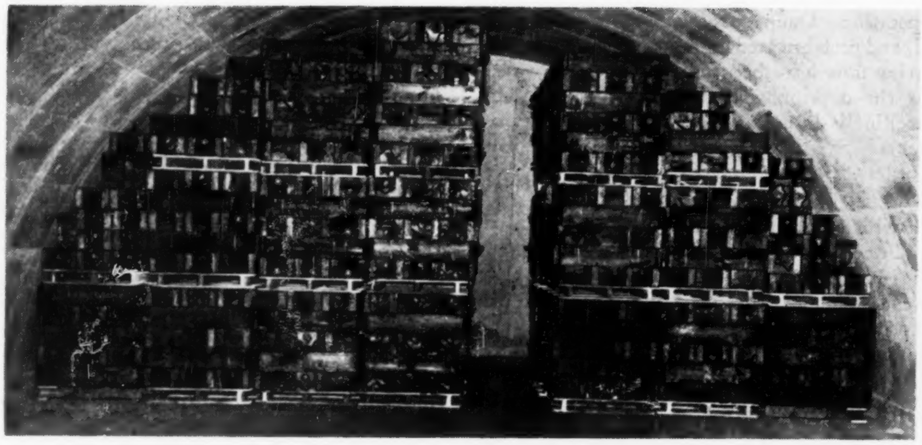

FIG. 15 CONTOUR STACKING OF BOXED 105-MM HOWITZER AMMUNITION DESIGNED FOR MAXIMUM SPACE UTILIZATION IN AN IGLOO MAGAZINE

Before After

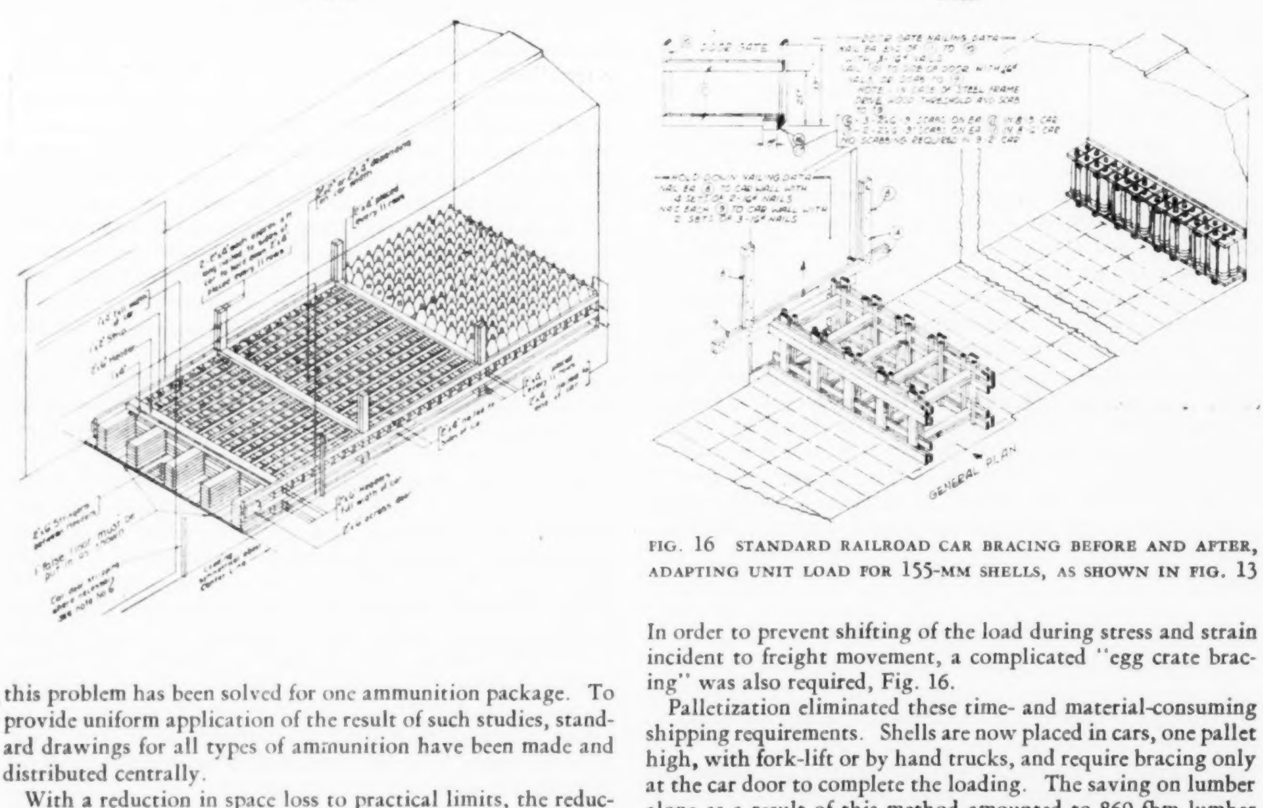

FIG. 16 STANDARD RAILROAD CAR BRACING BEFORE AND AFTER, ADAPTING UNIT LOAD FOR 155-MM SHELLS, AS SHOWN IN FIG. 13

this problem has been solved for one ammunition package. To provide uniform application of the result of such studies, standard drawings for all types of ammunition have been made and distributed centrally.

With a reduction in space loss to practical limits, the reduction in man-hours accomplished through the reduced number of handlings by palletization over individual item handling stood out boldly. A case in point was the 105-mm howitzer shell which consumed in handling 1.5 man-hours per ton before palletization, against 0.9 man-hours per ton after palletization. This represented a savings of 0.6 man-hours per ton or a labor saving of 40 per cent.

Advantages of palletization from the depot point of view may be further illustrated. Before separate-loading shells were palletized, shipping requirements called for the construction of false flooring in railroad cars, since experience had shown that the floor of the average freight car was not completely level. In order to prevent shifting of the load during stress and strain incident to freight movement, a complicated "egg crate bracing" was also required, Fig. 16.

Palletization eliminated these time- and material-consuming shipping requirements. Shells are now placed in cars, one pallet high, with fork-lift or by hand trucks, and require bracing only at the car door to complete the loading. The saving on lumber alone as a result of this method amounted to 869 fbm lumber per car or 70 per cent of original requirements.

Advantages of unit load development, such as just cited, are of such a magnitude that Ordnance was rapidly moving forward to handle all ammunition on pallets from manufacturer to overseas ports.

Lumber Salvage. The enormous quantities of lumber required for shipping, and the scarcity of the commodity itself, have led to a considerable devotion of effort to salvaging any lumber received in shipment which does not meet prefabricated specifications. Particular emphasis was placed on this aspect of the problem before the general adoption of prefabricated dunnage. As a result, the salvage of dunnage has become a well-organized

mass-production operation. Dunnage received in incoming cars is denailed, shaped, and prefabricated for re-use. Obstacles to a continuous production flow have been relieved in many ways, one of which was the development and use of a denailing machine. This machine is in use at a number of field service depots and has been adopted in turn by the Navy Department which has placed orders for the manufacture of a large number of them.

The success with which this problem was attacked is shown by the experience of one depot which in 1 year used 8,000,000 fbm of dunnage that had been reclaimed. Only 2,000,000 fbm of new lumber were used during the same period. This resulted in a considerable cost saving (a close estimate, after deducting cost of reclamation, would approximate $160,000), and a corresponding decrease in the strain on lumber supply.

Full-Round Crews. One other factor of similar importance is the indirect operation common to many depots which involves unloading of material at the dock, transportation of it to the storage point, and unloading of the ammunition at that point. This introduced a problem in the early stages of depot development that involved the identity and distribution of crews. In many depots separate crews, each with its individual foreman, were placed at the docks and at the igloo. This arrangement failed to provide an integrated effort that would overcome operational delays inherent in an activity carried on at two different points, the effectiveness of which was a function of the effectiveness of the crew members at both ends of the line. This led to the development of a full-round crew under a single foreman, split to handle both ends of the operation.

Responsible supervision was then interested in the complete operational cycle which resulted in the elimination of many minor delays and a smoother flow of materiel. The handling time was correspondingly reduced.

Consistent efforts made to effect practical solutions of existing ammunition-handling problems, some of which still remain unsolved because of their inherency in the nature of the operation, have resulted in an excellent record of accomplishment in terms of operational effectiveness. During the past two years notable progress has been made in increasing the amount of ammunition tonnage shipped to the battle fronts, this increase being accompanied by as much as a 40 per cent reduction in the labor cost per ton handled. Continuing attacks on the problems that still exist and continuing emphasis on economy of operation are expected to improve the record already made.

HANDLING GENERAL SUPPLIES

More than 250,000 different articles, each varying in size, each designed to perform a distinct function, and representing the products of hundreds of manufacturers, constitute the background from which spring the handling problems of a general-supply depot. These problems are so extensive and varied that no attempt will be made to give them comprehensive treatment within the limits of this paper. A pointing-up of these which have received major operational attention must suffice.

For an objective survey, no better way can be found than to look at the operation of a master Ordnance depot, which is the principal source of supply for all stock items within its mission. Customer lists of such a depot will include every link in the supply chain, domestic or overseas, wholesale or retail. The special problems which will be discussed are manifestations of underlying characteristics of the Ordnance general-supply activities and include the following:

1 Necessary variation in requirements and type of demand between overseas and domestic stations.

2 Large number of stock items which, at a single major depot, will exceed 100,000, with wide variations in quantity and dimensions.

3 Identification and disposition of items no longer needed for the maintenance of equipment.

The impact of these fundamental characteristics will be implied throughout the subsequent discussion.

Spare parts, tools, supplies, and equipment can be divided into two main groups: Those items which can be stored in a bin because they can be handled without the aid of mechanical devices; and those items which, because of their size and weight, cannot be stored in bins and require mechanical devices in handling.

Bin Storage. The layout of bin storage has received considerable study and attention. Layouts and methods have been developed to meet Army supply requirements which are entirely new and represent an advancement over practices generally employed by industry before the start of the war.

In order to obtain the best use of bin space, three fundamentals must be considered, i.e., size of the piece, number of pieces in a standard exterior container, and the frequency with which the piece is required by the using agency.

Emphasis on flexibility in the storage plan is the key to an effective depot operation, because of assignment changes under an installation's mission to accommodate fluctuating requirements of widely separated theaters; changes of supply requirements for specific items, resulting from the varying experiences in the recent war; and revisions to the stock-numbering system as a result of continuing research on interchangeable parts. Industrial layouts which call for the storing of material by part-number sequence in size groupings, or the storing together of material through the grouping of products of specific manufacturers, or the storing of material by grouping like items were all exhaustively studied, weighed against requirements of the Army supply program, and found wanting. Today's practice is based on the principle that storing of material in bins must be determined by size and frequency of issue alone. Practical experience has proved the binning of material by size and frequency of issue meets the paramount need for flexibility.

The planning of bin installations has been reduced to rather exact lines of attack. Because of the wide variety in piece size the planning of bin storage must result in a wide variety of bin arrangements. Bins are provided in 16 standard sizes, ranging from a unit which has 84 openings, 6 in. in height, 6 in. in width, and 12 in. in depth, through a series of progressive dimensions to a size having only 4 openings, 21 in. in height, 36 in. in width, and 36 in. in depth. Special rack-type bins are also provided for such items as rifle barrels, fuel lines, and steering-gear columns. These bins range from 4 openings, 21 in. in height, 36 in. in width, and 36 in. in depth, up to 21 openings, 12 in. in height, 12 in. in width, and 72 in. in depth. All bin units are 3 ft wide × 7 ft 3 in. high.

In setting up a bin-storage area, considerable study has been given to the question of aisleways. Experience has proved that the best use of space is obtained when an aisle 30 in. wide is used between small bins, while a 36-in. aisle is most practical between large bins, and a 60-in. aisle is necessary between rack-type bins. In storing by piece, size, and frequency of issue, the bins are arranged in the storage area with the small binned openings nearest to the shipping activities. The bin sizes are then graduated in accordance with the size of the pieces to be stored so that the largest items are found in the bins most remote from the shipping activity. The issue frequency of large items, almost without exception, is less than the frequency of demand for smaller items.

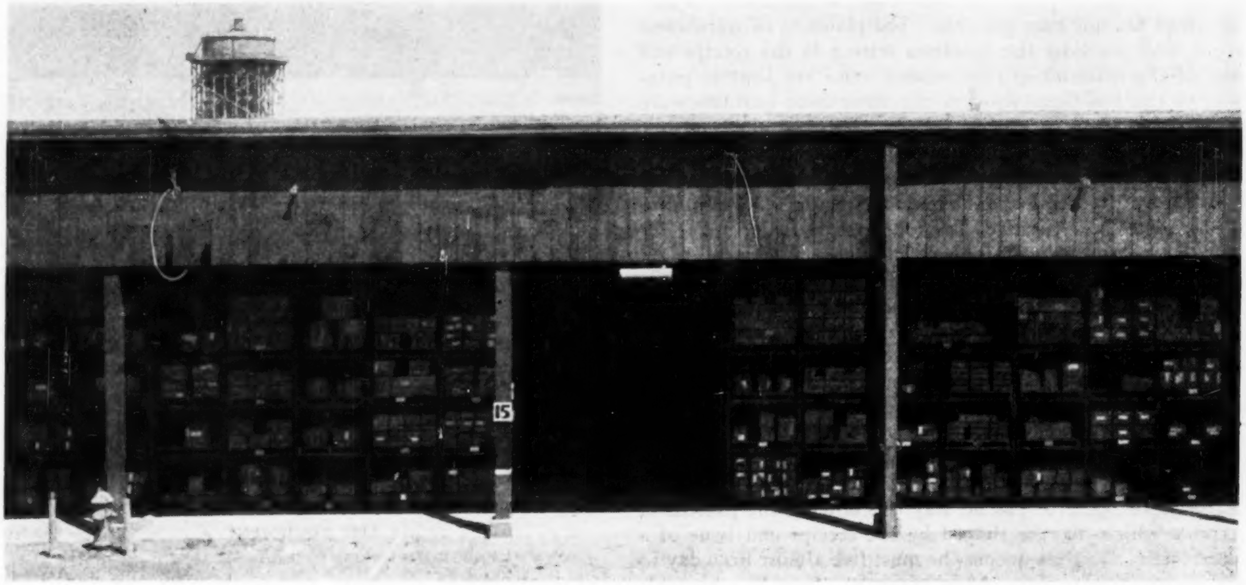

FIG. 17 PALLET RACK STORAGE OF BIN-RESERVE AND LOW-ACTIVITY BULK ITEMS IN OPEN SHED OF WEST COAST DEPOT

The number of bin openings will be determined by the number of items which the installation is authorized to store. In a diversified installation, as many as 130,000 bin openings, with every available bin dimension, have been set up.

Preplanned bin arrangements must be established before the first boxed material can be opened. This plan is prepared by technical experts in the office of the depot locator. These experts study each authorized item to determine the size and frequency of issue and design accordingly. As the thousands of items begin to arrive at the depot, receiving documents, which normally come well in advance of the shipment, are passed across the files in the chief locator's office. Here the location of every item has been recorded on a card and that location, accordingly, can be entered opposite the item on the advance copy of the receiving document. When the stock itself is received, a tag is affixed to each container of like items, giving the location of the bin selected for storage. The materiel, upon arrival at the bin area, is delivered to the bin in the same manner that a postmaster delivers a letter when he knows the city, street, and number of the individual to whom the letter is addressed.

The location system employed at Ordnance Field Service depots applies not only to bin storage but is extended to include the control of boxed parts stored in bulk warehouses. Each item has a prime, or master, location reflected on the stock record card in the stock-accounting office, on a location card in the locator's office, as well as on a location card at the point of storage. Reserve locations to accommodate the overflow are likewise recorded so that replenishment can be effected quickly, and quantities greater than may be accommodated by the bin can be located and used with a minimum of searching and handling.

Selection and Picking. When stock is to be issued, the shipping document and the picking tag are prepared by electric accounting machines in such a manner that the items appear on the document and on the tags in sequence of their location, as opposed to a sequence in terms of a part number or application groupings. This prearrangement holds the movement of the stock pickers to a practical minimum. Materiel picked from bins is placed on a four-wheel pushcart and brought by the picker to a consolidation point for forwarding to the packing line.

Final boxing of bin items represents a special problem. Materiel returned from field stores, despite rigorous precautions, will find its way into bin stores and, upon selection, will prove to be inadequately protected for export shipment. Normal handling of materiel in the process of receipt, storage, and shipment will destroy the prepacking so carefully performed by manufacturers or depot packaging facilities. As a result, supervision at the packing line must be continually watchful for improperly packaged materiel and adequate provision made for proper packaging before items are packed for final shipment.

Standard-size boxes are used whenever possible. However, the wide variation of item size and dimension is a complication in the packing of small objects, such as exhaust pipes, fuel lines, and housings, which makes building of custom boxes on the spot necessary.

Bin-Reserve Storage. The binnable item, by its very nature, is usually light and easy to handle when found in the loose-issue form. However, a shipment of many pieces in the standard Ordnance pack results in a handling problem which brings with it the necessity for bulk-storage methods. Stock densities vary widely when regarded in terms of boxes to be handled. A container of 1 cu ft, weighing less than 50 lb, will hold the maximum stock level of a depot if the item happens to be hair springs for watches. On the other hand, taking the example of an oil-filter element, the stock level may represent 10 carloads of boxes each containing 25 pieces of the item. Meeting this wide variation in stock density, reserve stores of binnable items must be treated in a special way.

When the reserve stock consists of only one box, the reserve location may well be on top of the bin containing the loose-issue quantity of the item. Warehouse plans for the storage of bin-reserve materiel must be adjusted to meet the need in terms of the stock density of each item. The extensive use of marginal storage space on aisles is indicated, Fig. 17.

Mechanical contrivances, such as box pallets and pallet racks, play a big part in bin-reserve storage. However, because of the various quantities in which items may be ordered,

the development of pallet-size unit loads, as in the case of ammunition, has not been possible. The planning of warehouse layout must consider the problems arising in the receipt and issue of the materiel so that related items are kept in proximity to the buildings wherein the loose-issue quantities are stored.

This problem calls for continual study and refinement on the part of the storage operator. At a typical installation, it has been met by allocating specific buildings to the storage of bin-reserve items in a pattern based on selected major items for which there is a heavy spare-parts activity. Under this plan, parts listed in the standard nomenclature list (catalogue) for the major item are used as a nucleus for establishing the bin-reserve-storage setup. These nuclei are then surrounded by satellite items, found to be most frequently issued on requisitions for parts applicable to the basic major item. This plan has proved operationally sound since a minimum amount of breakdown and distribution of the contents of inbound cars is required and a corresponding concentration of issue activity results.

The depot operator has no way of knowing the pattern of activity which may be shaped by the receipt and issue of a special item. In consequence, he must live almost from day to day in storage planning. As an example: Item X, a binnable item, is first received at the depot in a very small quantity in a multiple-pack container. A master bin location is established. Two weeks later, a shipment of the same item is received, consisting of five boxes containing 20 pieces each. These boxes are stored in a reserve location in a pallet rack or box pallet. Three weeks later, 20 boxes of the same item are received, and it is necessary to withdraw the second receipt, combine it with the third receipt, and select a marginal location where a tier of the item is established.

FIG. 18 TWELVE GAS CYLINDERS UNITIZED FOR STORAGE AND SHIPMENT

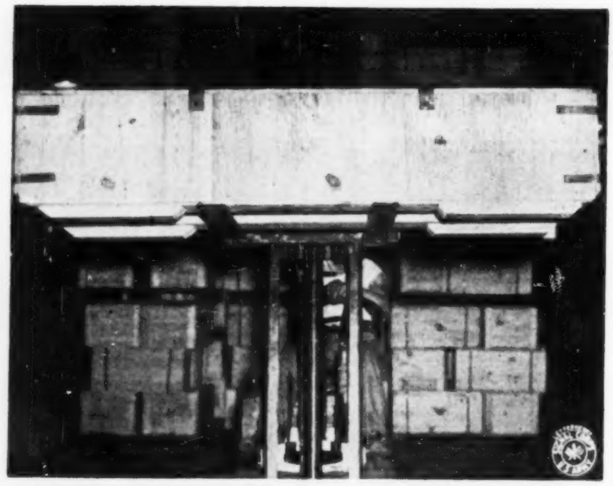

FIG. 19 HALF-SKIDS ON HEAVY BOXES FACILITATE USE OF FORK-LIFT EQUIPMENT

Two weeks later a half-carload of the same item is received, which expands the single tier into three. After an interval of another 2 weeks, a solid carload of the item is received, and the three tiers must be transferred into a bay. The item now consumes 400 sq ft of storage space.

It can be said, therefore, that the storage of Ordnance general supplies is not a static, but rather a living, breathing activity which is constantly expanding and contracting.

Bulk Storage. For practical purposes, the storage of binnable reserve items of supply can be considered as a bulk-storage problem. However, another type of bulk storage is found in the handling of items which are too heavy and too large to be stored in bins. Here again, the special problems resulting from variation in stock density, variation in container size, and changes in official stockage number play a part.

The constant emphasis placed upon the attainment of maximum utilization of manpower, space, and equipment made necessary the continuing study of storage plans, location systems, and handling methods. The size and weight of items determine the size and capacity of mechanical handling equipment needed to receive and store materiel.

Only in the case of bulk handling of general supplies is it possible to approach the labor economies of ammunition handling effected by palletization. Palletized storage and unit-load development of small handling units is fully exploited, Fig. 18, and containers for the larger items, which are "unit loads" in themselves, are designed, Fig. 19, to facilitate handling by fork-lift equipment.

Inventory. In order to maintain accurate stock records, War Department policy dictates frequent physical inventories on a special and cycle basis which further complicates the storage problem. The need for frequent and accurate inventories has long since been recognized by storage personnel as the basis for accurate determination for procurement, normal supply, and the disposition of surpluses.

Inventory requirements have a bearing on storage layout and methods. Since specific items may come to the depot packed in a variety of container sizes, special precautions must be exercised to store the materiel in such a manner as to result in a segregation of containers based on the number of pieces within each box.

Open Storage. While the practice of storing selected items of Ordnance materiel in open areas has long since been in effect, new emphasis is now being placed on the utilization of this type of storage. Staff agencies at all supply levels of the War Department are keenly aware of the storage problem which will be created by the return of vast quantities of supplies from overseas.

A careful examination of items which can withstand the rigors of outside storage is being carried on and the chiefs of Technical Services throughout the supply system are focusing attention on inside storage space that must be vacated by the movement of selected items outdoors if the over-all space need is to be met.

It is evident that many items which have been packaged for export shipment will withstand outside storage, if special precautions are observed. In determining the items which may be removed from the protection of typical warehouse storage, the following questions must be answered:

How adequate is the protection afforded by the export packing?

Must climatic conditions at the specific installation be considered?

Is the item such that it can be stored satisfactorily in a shed, in the open covered with a tarpaulin, or in the open without protective cover?

Typical of items which may be stored in the open are vehicles, nonferrous sheet and bar stock, painted wood or metal frames, heavy rough castings, and chemicals in drums or pails. Items which would withstand open storage when protected by tarpaulins or sheds include many export-packed vehicle parts, tools, and equipment, combat-vehicle track, hardware, and empty chests, such as those used for tools or ammunition.

The layout of open storage space presents the same problems met in the warehouse, namely, the maximum utilization of stacking heights within the capacity of the mechanical equipment and good access, so that receipt, issue, and inventory operations can be carried out with a minimum of handling.

Much progress has been made and definite specifications laid down to carry out these specific objectives. The outside storage of vehicles, for example, has become standardized to the extent that standard operating procedures have been developed for all phases of the vehicle-storage activity.

Overseas Packaging. A discussion of the scope of the packaging problem was presented in a previous section, where there were described the great distances materiel must be shipped, repeated handlings to be undergone, exposure to all extremes of unfavorable weather, and attacks by bacteria and insects. Centralized research developed numerous standard specifications to meet various packaging requirements, the variation between methods being primarily related to the characteristics of the item packed, rather than conditions to be met.

Almost all items are packaged by the manufacturer in conformity with Ordnance specifications for overseas shipment. However, a large depot-packaging problem still remains because items returned by troops must be repackaged to original specifications and packaging damaged in storage must be replaced.

A description of Ordnance's packaging techniques, developed during this war, merits a paper in itself. Pending the preparation of such a paper, it is pointed out here that general-supply master, filler, and distribution depots must maintain adequate facilities as follows to perform the basic processes, for items ranging in size from a set of piston rings to a 155-mm field gun:

1 The materiel must be thoroughly cleaned.

2 Preservatives which will stop chemical action and withstand attacks of parasites, insects, and bacteria must be applied.

3 Materiel must be wrapped in such a manner that the preservatives do not escape, the attacking elements do not reach the materiel, and adequate protection is furnished against mechanical damage.

4 The materiel must be combined in exterior containers, taking into consideration the unit of issue to the lowest echelon of use, so that the size and weight of the container will permit easy handling and stowing during transportation, and so maximum economy in space utilization will be effected.

SUMMARY

Peculiarities applicable to the handling of various categories of Ordnance materiel have been discussed. Except for binned general supplies, however, one comment is applicable to all, namely, Ordnance believes palletization and unit-load development is universally desirable and is making every effort to complete the palletization program.

The Future Supply of Scientific Personnel

(*Continued from page 126*)

research scientists so that they may be prepared to begin their contributions at the height of their powers.

We are aware that most of the great contributions by our outstanding scientists have been made relatively early. Newton, for example, contributed the law of gravitation, his studies on the spectrum of light, and the calculus when he was 23 and 24, and speaks proudly of these years as the height of his powers. He had retired from science at the age of 27. Many of our Nobel Laureates had completed the work on which their fame rests at such ages as 21 and 22. Professor Pressey of Ohio State has, as you may know, published studies on the relationship between creative research and age and concludes that for the sciences we represent, the most fruitful ages are those of early maturity. The golden ages are between 20 and 30. He concludes that we should try to turn out our scientists at least two years earlier than has been customary in peacetime.

This has particular application to the present situation because the opinion is so generally stated that a year or two of military discipline is good for a boy, and that the country has benefited through having had its youth undergo the rigors of war. I have no opinion on this point at this juncture, but the evidence seems to indicate that the scientific competence of the nation is definitely not enhanced by the interruption of the scientific careers of our young men. On the contrary we shall probably have lost not only in numbers, but in the average powers of each.

CONCLUSION

I should like to conclude by stressing the thought that the issue we have faced during the war is and will be with us to some extent from now on. It behooves us to present the point of view strongly that scientific and technical personnel will from now on be an increasingly important component of our national well-being. To develop and utilize this national resource requires a policy based on a frank realization of the need to stimulate training in these fields. The demands of democracy and technology are by no means incompatible but merely require intelligent efforts to meet them both.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Honors

Philip Sporn

THE Edison Medal for 1945 has been awarded by the American Institute of Electrical Engineers to Philip Sporn, member A.S.M.E., executive vice-president, American Gas and Electric Service Corporation, New York, N. Y., "for his contributions to the art of economical and dependable power generation and transmission." Presentation of the medal was made on Jan. 23, 1946, during the 1946 A.I.E.E. winter convention.

The Edison Medal was founded by associates and friends of Thomas A. Edison and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee composed of 24 members of the American Institute of Electrical Engineers.

J. C. Lincoln

A silver plaque honoring John Cromwell Lincoln, member A.S.M.E., as founder of The Lincoln Electric Company, Cleveland, Ohio, was presented to him on Dec. 5, 1945, by the firm's employees to mark the company's fiftieth anniversary. Mr. Lincoln, who has resided at Phoenix, Ariz., for the past several years, is now chairman of the board of the company he founded 50 years ago. His brother, J. F. Lincoln, president of the company, is also a member of A.S.M.E.

Duodecimal Awards

The Duodecimal Society of America (see MECHANICAL ENGINEERING, October, 1945, pp. 675–676, has conferred its annual award for 1944 on F. Emerson Andrews, Tenafly, N. J., and for 1945 on George S. Terry, Hingham, Mass.

Mr. Andrews is publication manager for the Russell Sage Foundation and has written a number of articles on duodecimals, in addition to a book, "New Numbers." Mr. Terry, who received an engineering degree from the University of London, is the author of the "Duodecimal Arithmetic," "The Dozen System," and many papers on duodecimals as applied to the theory of numbers.

Joseph B. Ennis

On Dec. 11, 1945, Joseph B. Ennis, fellow A.S.M.E., was guest of honor at a dinner held at the Waldorf-Astoria Hotel, New York, N. Y. Mr. Ennis, who is senior vice-president of the American Locomotive Company, has just completed fifty years of service with this company. The subject of his address was "The Last Fifty Years—and the Next."

Presiding at the dinner was William Carter Dickerman, member A.S.M.E., formerly chairman of the board of directors, and at present a director of The American Locomotive Company. Other speakers included Charles J. Hardy, Alco director; Samuel G. Allen, chairman of the board of the Lima Locomotive Works; Paul W. Kiefer, member A.S.M.E., chief engineer of motive power and rolling stock, New York Central System; Charles Penrose, member A.S.M.E., senior vice-president for North America, the Newcomen Society; and D. W. Frazier, formerly president and recently elected chairman of the board of the American Locomotive Company.

Visitors

Albert J. Jadot

AMONG the distinguished visitors at the 1945 A.S.M.E. Annual Meeting was Prof. Albert J. Jadot, of the Faculté Polytechnique de Mons, who, as a member of the Belgian Technical Mission now in the country, listened with interest to the papers of the A.S.M.E. Oil and Gas Power Division.

Professor Jadot was a member of the Belgium resistance forces during the war. Lieut. Col. John J. Maginnis, U. S. Civil Affairs Officer for the Province of Hainaut, in a letter introducing Professor Jadot, said, "During the length of my service from October, 1944, to March, 1945, Professor Jadot's help and assistance was of the greatest value for he was highly revered by all parties as a man of sound judgment and honest conviction."

This was not Professor Jadot's first visit to New York for he was in this country about twenty years ago when he took his master's degree at Cornell in 1924.

"New York has changed for the better," he said. "I sense a great difference now—much more polish and beauty. Of course," he added with conviction, "New York is the capital of the world."

In 1947 the engineering alumni of the University of Liége are planning a great centennial celebration. The program of events is expected to cover several weeks. It will be the occasion of the first postwar convocation of Belgian engineers. Many foreign visitors are expected, and Professor Jadot said that he hoped the American engineers will honor Belgium by sending a delegation. At that time he hopes to be able to repay the courtesies shown him at the Annual Meeting.

Alex Engblom

Alex Engblom, fellow A.S.M.E. and works manager of the Borås Wäfveri Aktiebolag, Borås, Sweden, one of the outstanding textile concerns in Scandinavia, was present at the 1945 A.S.M.E. Annual Meeting to attend the technical sessions of the Textile Division.

At a time when many foreign engineers are being forced to drop membership in American technical societies because of the difficult exchange situation caused by the war, Mr. Engblom is actively engaged in the work of expanding A.S.M.E. membership in Sweden.

Mr. Engblom was in this country on a purchasing mission in the interest of the Swedish textile industry. As vice-president of the Swedish Committee of Scientific Management, he consulted with William L. Batt, past-president and honorary member A.S.M.E. and president of the American Committee of Scientific Management, about the forthcoming Eighth International Management Congress, which is to be held in Stockholm, Sweden, during the first week in September, 1946.

Mr. Engblom became a member in 1914 while he was employed by Sidney Blumenthal & Co., Sheldon, Conn. His American experience has given him an excellent understanding of American life and ways. He speaks English fluently.

As a prominent member of the Swedish engineering fraternity, Mr. Engblom is a member of the Royal Swedish Institute of Engineering Research, the Svenska Teknologföremingen, Stockholm, the American Society of Swedish Engineers, and fellow of the Textile Institute, Manchester, England.

Quality Control

W. A. BENNETT and M. Milbourn have recently been in this country as the successful candidates in a scholarship competition organized by the Quality Control Panel associated with the Midland Region of the British Ministry of Production, according to information provided by the Society for Quality Control.

This Panel, consisting of engineers practiced in the application of quality control, has been operating since 1942. It offers advice on quality-control and inspection techniques to all firms within the Midland Region, and it endeavors to stimulate and maintain interest in these subjects in addition to carrying out an educational program.

The Panel comprises representatives of a number of firms actually employing quality-control techniques. It is closely linked with the Ministry of Supply Advisory Service on Quality Control, and Regional Officers of this service serve on the Panel.

Through the courtesy of Dr. D. S. Anderson, principal, Birmingham Technical College, courses of lectures have been arranged which were designed to educate the engineers directly concerned with the introduction of quality control into the shops. All firms were sent a circular, in the form of a questionnaire, pointing out the advantages of quality control. Exhibitions were also held, sponsored by local industry, at which manufacturers, applying the technique, demonstrated types of products and methods of application. Measuring instruments were also exhibited.

One complete course of lectures, delivered mainly by men drawn from the region, was published by the Birmingham District Committee of the Ministry of Production as a Symposium of Papers on Quality Control, copies of which are still available.

These activities not only produced very useful results, but they also stimulated considerable interest in all spheres of industry. In order to maintain this interest, and also to give the people concerned an opportunity to discuss their problems in an informal manner, local discussion groups were organized. These have been active for the past two years, and they have extracted items for discussion from the organized lectures, in addition to their own problems.

The keenness which these activities engendered is admirably reflected in the scholarship scheme originated by the Panel and made possible through the generosity of local industry. A sum of money adequate to allow the two successful participants to spend three months in the United States studying quality control and statistical methods was collected and the scheme was fully publicized. It evoked great interest among practicing quality-control engineers, some 92 of whom submitted papers or essays on industrial applications of statistical methods, each one under a nom de plume. All the papers were considered by a board of examiners, under the chairmanship of A. W. Swan, Ministry of Supply, and six candidates were selected for interview. The examining board doubtless wished to select two people who would combine to form a team, and their success in this direction can be judged from the following details about the two who were eventually chosen.

W. A. BENNETT

W. A. Bennett, now works manager and formerly chief inspector of the English Needle and Fishing Tackle Company, Redditch, has been responsible for introducing and developing a very complete quality-control installation in his factory. This was originally directed toward process control, but it has developed until all sections of the organization are directly affected by the results obtained. He has experienced all the practical difficulties on the shop floor, but he has been fully alive to the wider implications of quality control, which has resulted in his promotion to the works managership, where he will have the opportunity of implementing his ideas. The installation in his factory has been studied by many people drawn from industry and government departments, and his services have been given frequently not only to the Quality Control Panel of which he is a member but also to other interested bodies, as a lecturer on the practical application of quality control.

MAURICE MILBOURN

Maurice Milbourn, on the other hand, is employed as a physicist in the Research Department of Imperial Chemical Industries, Metals Division, Birmingham. His interest has been directed more toward the theoretical aspects of statistics, including methods other than quality control. He was trained at the Imperial College of Science and Technology, London, where he was graduated in physics, and his work has been mainly in the fields of spectrographic analysis and physical metallurgy.

The scholarship scheme was confined to people employed in industry in the Midlands and Mr. Milbourn and Mr. Bennett are therefore representatives of industry, as well as being sponsored by it.

Owing to the cessation of hostilities it is likely that the activities of the Ministry of Production may cease, since it was a wartime department. As the Quality Control Panel is serving so useful a purpose, it is hoped to insure its continuity by linking it with the Industrial Applications Group of the Royal Statistical Society which is extending its sphere of activity by the formation of local sections throughout the country.

A.S.R.E. Education Report

AT the recent convention of the American Society of Refrigerating Engineers, held in New York, N. Y., the A.S.R.E. Committee on Education presented a useful and comprehensive report, "Educational Guide to Refrigeration and Air-Conditioning Training Facilities in the United States." The report, A.S.R.E. Misc. No. 6, appears as a supplement to the January issue of *Refrigerating Engineering*, monthly journal of A.S.R.E.

The report consists of an explanatory foreword and seven tables, as follows: (1) University or college courses in refrigeration and air conditioning; (2) vocational and trade-school courses in refrigeration and air conditioning; (3) university or college extension courses in refrigeration and air con-

ditioning; (4) university or college graduate work available in refrigeration and air conditioning; (5) university or college laboratory facilities in refrigeration and air conditioning; (6) university or college technical aide courses primarily or exclusively for veterans; and (7) university or college correspondence study courses in refrigeration and air conditioning.

The educational guide will be a welcome addition to guidance literature for the use of teachers, vocational counselors, and persons seeking educational opportunities in the fields of refrigeration and air conditioning. It should prove to be particularly useful to returning veterans who look to these fields for future careers and who need additional training in them.

Georgia Tech Graduate Studies

IN order to fill the needs of industrial, research, and educational organizations in Georgia and the South for engineers and scientists with graduate training, the Georgia School of Technology, Atlanta, Ga., is expanding considerably its Division of Graduate Studies, starting with the opening of the spring term on March 4, 1946. In connection with this plan, the Division is offering a series of graduate awards, ranging up to $1800 per academic year, in engineering and allied sciences to qualified graduates of Georgia Tech and other colleges and universities in the United States. Dr. Robert I. Sarbacher, Dean of the Division of Graduate Studies, is in charge of the program.

In general, the awards will consist of research fellowships, graduate fellowships, research assistantships, graduate assistantships, and part-time instructorships. The fields of study and research open to recipients of the awards will include aeronautical, architectural, ceramic, chemical, civil, electrical, general, industrial, mechanical, public health, safety and textile engineering; architecture; chemistry; engineering mathematics; industrial management; and physics.

The part-time instructorships will be granted to mature individuals qualified to teach or assist in teaching at college level, who would like to obtain experience and advance themselves in the field of engineering and scientific education. Work in connection with the award will consist of part-time teaching under the direction of experienced engineering and scientific educators. Sufficient time will be available to take a maximum of nine semester hours of advanced studies. Because of its character, the position does not carry academic rank. The award for a nine-months' academic year ranges from $1000 to $1800.

Research fellowships will be granted to those with high scholarly attainment, experience in research, and proved ability in their field. Since these students are expected to have more interest in research work than in remuneration, the award will be in accordance with the individual requirements. The graduate fellowships, which do carry a grant, will be given to deserving graduate students with two or more semesters of graduate work at recognized schools, colleges, or universities. Complete opportunity will be given to them to devote full time to advanced studies and research work. The award for a nine-months' academic year will range from $600 to $800.

Research assistantships will be granted to students with bachelor's degrees and experience applicable to research in process or projected. Their research work will require fourteen hours of work a week. The remainder of their time can be devoted to advanced studies. The award for a nine-months' academic year is from $650. Graduate assistantships are to be given to students with Bachelor's degrees. Their work will consist of 14 hours of service a week as assistants to instructors and in laboratories. A maximum of 12 semester hours of advanced studies can be carried. The award for a nine-months' academic year is from $650.

Naval Exhibit

A VISIT to the Naval Research and Inventions Exhibit, currently being held at the Museum of Science and Industry in Rockefeller Center, New York, N. Y., should prove worth while and extremely interesting. For the first time in some cases there are being demonstrated and exhibited such wartime secrets as radar, atomic power, jet-propulsion, guided missiles, proximity (V.T.) fuses, and representative achievements of the Special Devices Division of the Naval Research Laboratory and the Office of Scientific Research and Development.

Drawn upon for the show were the vast facilities of the Naval Research Laboratory of which Rear Admiral H. G. Bowen, U.S.N., Honorary Member A.S.M.E., is director and Rear-Admiral Luis de Florez, U.S.N.R., member A.S.M.E., is assistant director. Both are well known in scientific and engineering circles.

As one enters the exhibit, a huge three-dimensional display of the structure of an atom of Uranium 235 is seen suspended over the stairway. This single representation of the atom is magnified more than 279 billion times and shows the relationship of the various atomic units to each other.

The ultra sonic trainer, actually a miniature radar system, also on display, employs models of enemy-held territory. It is used to train air crewmen in navigation and bombing so that the crew know "the look and feel" of the territory before going on

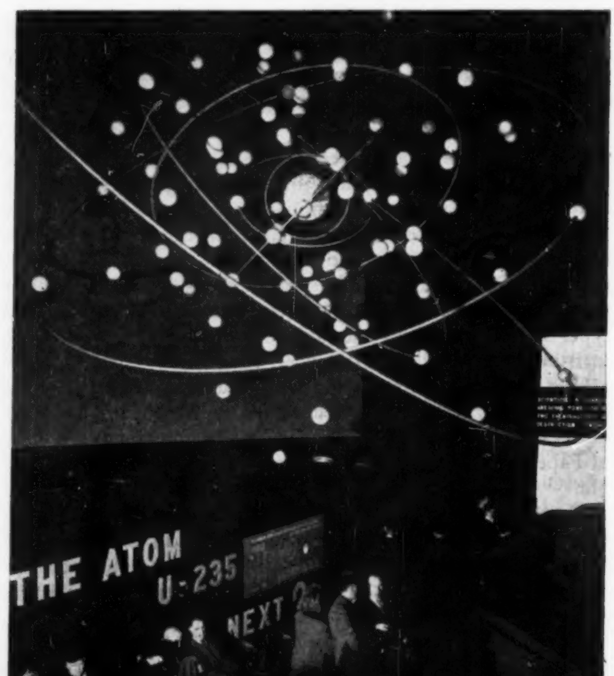

FIG. 1 MODEL OF AN ATOM OF URANIUM 235, ENLARGED 279 BILLION TIMES, ON DISPLAY AT THE MUSEUM OF SCIENCE AND INDUSTRY, NEW YORK, N. Y., AS PART OF AN EXHIBIT SPONSORED BY THE NAVY OFFICE OF RESEARCH AND INVENTION

FIG. 2 RADIO AND TELEVISION CONTROLLED GUIDED MISSILE, THE POWERFUL "ROC" OF THE U. S. NAVY, AT THE MUSEUM OF SCIENCE AND INDUSTRY, NEW YORK, N. Y., PART OF AN EXHIBIT SPONSORED BY THE NAVY OFFICE OF RESEARCH AND DEVELOPMENT (*Left to right:* Fleet Admiral Willaim F. Halsey, Jr., Vice-Admiral Theodore Wilkinson, U.S.N., and Rear-Admiral Harold G. Bowen, U.S.N., Director of the Navy Office of Research and Invention, honorary member, A.S.M.E.)

their mission. With the device are 16 extra scopes so that the spectators can see how a bombing run over Manhattan is conducted by radar.

On display with various rockets is the "Gargoyle," a guided missile, with a speed of more than 600 miles per hour. A steep-winged dive bomber, the "Gargoyle" is jet-propelled and with its thousand-pound, armor-piercing bomb, automatically seeks out and collides with a ship target. Also being shown are captured German missiles and various German jet engines.

FIG. 3 REAR-ADMIRAL HAROLD G. BOWEN, U.S.N., AND LUIS DE FLOREZ, U.S.N.R., DIRECTOR AND ASSISTANT DIRECTOR, NAVY OFFICE OF RESEARCH AND INVENTION. ADMIRAL BOWEN IS AN HONORARY MEMBER AND ADMIRAL DE FLOREZ A MEMBER OF A.S.M.E.

Then there is on exhibition for the first time the proximity (variable time) fuse, rated second only to the atom bomb as the greatest scientific development of the war.

The remote fire control of a 40-mm dual mount antiaircraft gun using only ammunition loaders as a gun crew is demonstrated. The gun, electrically connected with a MK-51 gun director equipped with a gyroscopic sight, is controlled from the director.

Engineers will find many other developments to interest them and the effects that these developments will have on peacetime civilian life are demonstrated at the exhibit. A radar planning device using a terrain model may be seen. The "shark chaser," a chemical developed by the Naval Research Laboratory, which chases sharks, thus protecting downed fliers and men in rubber lifeboats, is on display. The growing process of man-made crystals, used for underwater sound equipment in place of quartz, is demonstrated in various stages. There are still other items of interest too numerous to outline here. However, a trip to Rockefeller Center to witness the advances made by science during the war years will be valuable and informative to those that are fortunate enough to attend.

The exhibit opened on Dec. 15, 1945, and will continue through March, 1946.

New Microfilm Machine

A NEW microfilm machine, known as the Duplex Recordak and intended for use in banks and offices, which simultaneously photographs the front and back of a business document, reducing its area by 1000 times, was demonstrated on Dec. 4, 1945, at the Sherry-Netherland Hotel, New York, N. Y., by Recordak Corporation, subsidiary of Eastman Kodak Company. The images appear side by side on narrow 16-mm film.

The trick of photographing both sides of a document at the

same time is done with mirrors. The front and back of a piece of paper are reflected simultaneously in the camera and are recorded side by side on the film.

Both sides of one hundred bank checks or reference cards can be reproduced on one foot of 16-mm microfilm, or more than eight an inch. On a 100-ft roll, more than 10,000 checks (front and back), three times as many pictures as were possible with previous models, can be photographed. A duplicate roll of film can be exposed at the same time, since the film unit has two lenses and holds two rolls of film.

The new machine will also endorse bank checks. Placing an endorser mechanism inside a microfilming machine is a new departure expected to save considerable time and work in banking procedures, by eliminating a separate operation.

A third job the machine does is to face-stamp "Photo by Recordak" on each document. Thus papers which might become involved in legal proceedings are known to be "filed" on microfilm.

Although designed principally for bank use, this machine has many applications in business and industry. Such documents as filed and canceled checks, ledger sheets, card records, and all papers that contain information on both sides, lend themselves to microfilming.

This new machine can also be used for photographing only one side of business papers at a less reduction. By merely changing the film unit a reduction in area of about 300 times can be obtained on 16-mm film and thus two rolls can be made simultaneously—one for safekeeping in a vault and the other for day-to-day reference.

Magnesium Alloys

BECAUSE of a false impression widely held that magnesium alloys are poor in the quality of resistance to corrosion, J. D. Hanaowalt and C. E. Nelson, The Dow Chemical Co., in their paper "Corrosion Stability of Magnesium Alloys," *Light Metals*, October, 1945, claim that the uses of magnesium are unnecessarily inhibited.

This erroneous impression, they believe, is due to the almost universal practice of subjecting materials to the salt-spray test as a measure of resistance to corrosion and extrapolating these data to resistance under all atmospheric conditions.

Unlike many other metals, the use of accelerated tests for laboratory studies does not lend itself to magnesium-alloy testing because of the great difference in degree between the action of salt water on magnesium alloys and the action of ordinary atmospheric conditions. Because of this great difference and because of the dominating effect of the large potential differences caused by impurities in common magnesium, the correlation of laboratory tests with atmospheric exposure is particularly misleading.

There are on record castings of magnesium alloys that have been exposed to atmospheric conditions for 15 years, which do not show any evidence of serious deterioration. The authors feel that when magnesium is better understood and utilized and when the corrosion fears have been allayed by its good service record, there will be many fields of application for which controlled purity of the metal is unnecessary.

Based on extensive tests reported by the authors, the following conclusion is reached:

"Common magnesium alloys, regardless of their purity, are extremely resistant, even when unprotected, to the corrosion attack of ordinary atmospheres. When painted and protected in the recommended manner, they will show negligible change in appearance and properties after 10 years of atmospheric exposure.

"If maximum resistance to salt-water corrosion, either in the form of coastal or shipboard atmospheres or direct immersion be required, it is desirable to control the purity of the alloys to within the tolerance limits outlined in an earlier paper of the authors. If the alloys be of controlled purity there is no harmful effect in the usual heat-treating or aging procedures."

Redecorated Ceiling

NEW YORK CITY'S famous Grand Central Terminal, after 33 years, has redecorated its high arched ceiling of the main concourse, so that the symbolic view of the heavens, with stars, the Milky Way, and the signs of the Zodiac might again be better presented to the public.

Railway Engineering and Maintenance describes the effective method and manner in which the New York Central undertook and completed the task of redecorating the expansive ceiling.

First, a scaffold had to be erected. To carry out this work a contract was awarded to the same company which erected the scaffold when the ceiling was originally decorated. This was accomplished by suspending the scaffold by steel cables extending through holes in the ceiling, the holes having been provided in the original construction. The cables supporting the scaffold were fastened by means of eyebolts to angles which were bolted to the roof trusses or to the roof purlins which support the ceiling. The work of erecting the scaffold was done at night, roping off only small areas of the concourse floor each night beneath where the scaffold was being placed. Throughout, the scaffold was constructed of Tubelox, a patented tubular steel scaffolding, with $1^1/_2$-in. salt-treated planking. The ceiling scaffold, 270 ft × 120 ft, was hung about $5^1/_2$ to 6 ft from the ceiling face and was supported by 600 $^1/_2$-in. cables, extending through the ceiling to the tubular scaffold members below. The cables in each case were doubled back at the ends and were secured by Crosby clips, approximately 2400 such clips being used. As the scaffold was placed, which required a period of two months, sufficient lights for illumination purposes were installed.

Railroad forces then cleaned off all dirt, scrapeda way all loose paint, and made a careful inspection of the plaster. Very few places showed signs of deterioration, and the plaster in general was found to be in exceptionally good condition.

The entire "blue-sky" section of the ceiling was then covered with Johns-Manville asbestos cement Flexboard. This was done to eliminate future deterioration of the plaster. The $^3/_{16}$-in. Flexboard 4-ft × 8-ft sheets were cemented to the ceiling, using braces from the scaffold floor to hold them firmly in place until the cement had set. In addition, the sheets were secured to the ceiling by means of heavy U-shaped steel wires which extended through small holes in the Flexboard upward through the ceiling to the $1^1/_4$-in. steel angles supporting the ceiling plaster.

All of the Flexboard was applied with its rough side facing downward to provide a better bond for the paint, and also to prevent any reflection from destroying the optical illusion of the sky.

The Flexboard was then coated with three coats of oil paint. The first coat of boiled linseed oil, a second coat of lead and oil with Patterson-Sargent Vita-Seal primer and sealer, and the third coat of lead and oil with titanium oxide, tinted a cerulean blue with a manganese pigment. A fourth coat similar to the third was also added to get the uniform depth of blue desired.

All of the paint was applied with brushes, and after the final coat, the blue was stippled with rather widely spaced daubs of various colors. This added to the depth of color when viewed

from a distance. For the Milky Way, a large number of white stipples were applied fairly close together. A total of 750 gal of paint was required for the four coats on the blue-sky ceiling and three coats of buff which were applied on the end sections of ornamental plaster.

The original decorative design of the stars, Zodiac, and signs of certain familiar constellations were outlined on the ceiling by using perforated template sheets of paper and by marking through the perforations with charcoal, after which the decorations were applied in gold leaf. A total of 10,000 linear feet of $^3/_4$-in. wide gold leaf was used for this purpose.

Individual illumination for the nearly 60 stars is provided by lights shining through unobstructed $^1/_2$-in. holes in the ceiling. The comparative brightness of the stars was obtained by placing a flat plate above each hole, between the light and the hole—the plate in each instance having a hole in it varying in size from $^1/_8$ in. to $^1/_2$ in. in diameter. With this arrangement dust cannot obstruct light, and such dust as does accumulate can be blown away if desired.

Removal of the scaffold was completed in about a month. After the scaffold was removed, small metal disks, painted blue and attached to wires, were pulled up to cover the holes through which the cables had extended, and the wires were fastened above the ceiling.

Starting this tremendous and expensive task in August, 1944, the ceiling scaffold was removed in June, 1945, revealing to the traveling public the reproduction of the heavenly constellations, brighter and more inspiring than ever.

Light Metal Stamping

WITH an ever-increasing trend toward the use of light metals in manufacturing, an article, "Flexible Tools for Stamping Light Metals," published in *Modern Metals*, August, 1945, should prove particularly interesting to manufacturers of items where lightness combined with strength is desirable.

Dealing primarily with the tooling problems of aircraft manufacturers and their solution, the article tells how wartime orders in the aircraft industry made old production methods obsolete and says that new techniques had to be developed. Prior to the war most airplanes were custom-built, necessitating a large amount of hand fitting. This called for skilled labor and resulted in noninterchangeable parts. The orthodox method of tooling for stamping airplane parts was costly and slow, and frequent changes in design, and varying quantities, led to the production of low-cost, relatively short-run dies and tools for forming, drawing, and piercing. Among various materials used alone or in combination are zinc alloys, plastics, rubber, and plywood. Parts produced by such tools have reduced requirements for highly skilled hand labor. It was possible to train unskilled labor to operate presses and assemble interchangeable stampings. Less critical material was required because there was a reduction in the amount of scrap produced as compared to hand operations.

One of the widely used zinc-base alloys is Kirksite. Developed in 1939 as a modification of a die-casting alloy, Kirksite is based on a sacrifice of fluidity in the interest of improved physical properties. This material casts in sand with great fidelity of detail and accuracy of dimension. Castings have physical properties not far below mild steel and shrink about the same as cast iron. They are easy to machine, polish, and weld, and lose none of their properties in remelting. This alloy has been used frequently for tools for blanking, forming, and deep-drawing aluminum. As many as 30,000 blocks of 0.062-in. duralumin have been made from one set of dies.

Plastic dies and tools have not been a "cure-all" for emergency tooling, but the use of plastics for dies and tools has made it possible to solve many difficult problems. In some instances they have proved more satisfactory than the metals they replaced.

The aircraft industry has pioneered in the development and use of temporary or "short run" dies and tools. The success with which their efforts have met is of greatest importance to the pressed-metal industry, the aluminum and magnesium industries, and to volume producers of equipment and appliances. These new stamping methods and techniques applied in airplane manufacture can be used with equal success by many other industries.

Automobiles

IN the September issue of *Light Metals* appears an article, "The Light-Alloy Automobile," which discusses (with "Notes and Commentary," by L. J. Pomeroy, technical editor of *The Motor*), the many practical advances made by France in the past few years toward the use of light alloys in the development of top-performing and economical automobiles.

Of particular interest is the F. W. D. Mathis car developed by L'Aluminium Francais. This vehicle, a three-wheeler, is designed strictly on aerodynamic lines, in order to obtain utmost reduction of wind resistance. Powered by a 530-cc overhead-valve engine, it has a claimed maximum speed of 70 mph and a gasoline consumption of 100 miles per gallon. Overall dimensions of the Mathis car are as follows: wheel base 7 ft 6 in., track 4 ft 11 in., and height 58 in.

The Mathis body and chassis form a single structure of light-alloy sheet built up from three principal pressings which are electrically welded together. The complete hull with doors weighs only $1^1/_2$ cwt and the total weight of the vehicle is less than 8 cwt. Of the latter some 40 per cent is light alloy.

This combined use of light alloys and the aerodynamic form effects a simultaneous reduction of both deadweight and drag, the light alloys taking care of the deadweight and the three-wheeler chassis assisting in the solution of the latter.

Marine Gas-Turbine Plant

A marine gas turbine plant sponsored by the U. S. Navy and constructed by the Elliott Company was described and its shop performance reported in a paper presented at the annual meeting of The Society of Naval Architects and Marine Engineers, by C. Richard Soderberg, professor of mechanical engineering, Massachusetts Institute of Technology, Ronald B. Smith, vice-president, Elliott Company, members A.S.M.E., and Lieutenant Commander Ashton T. Scott, research and standards branch, Bureau of Ships. The authors presented the same paper at a session sponsored by the Oil and Gas Power Division during the 1945 A.S.M.E. Annual Meeting, New York, N. Y., Nov. 26–29, 1945.

"The plant was first operated as a unit on Oct. 28, 1944, and following a period in which minor difficulties were corrected the test program began on Dec. 28, 1944. Since that time the unit has remained at the Jeanette plant for more detailed investigations in order to establish a background for developments in the future. The unit has operated a total of nearly 500 hours under load, including one continuous period of 48 hours."

Professor Soderberg said that the Elliott-Lysholm gas turbine plant was distinctive in two features: The basic cycle comprising intercooling, reheating and regeneration, and the use of the Lysholm compressor.

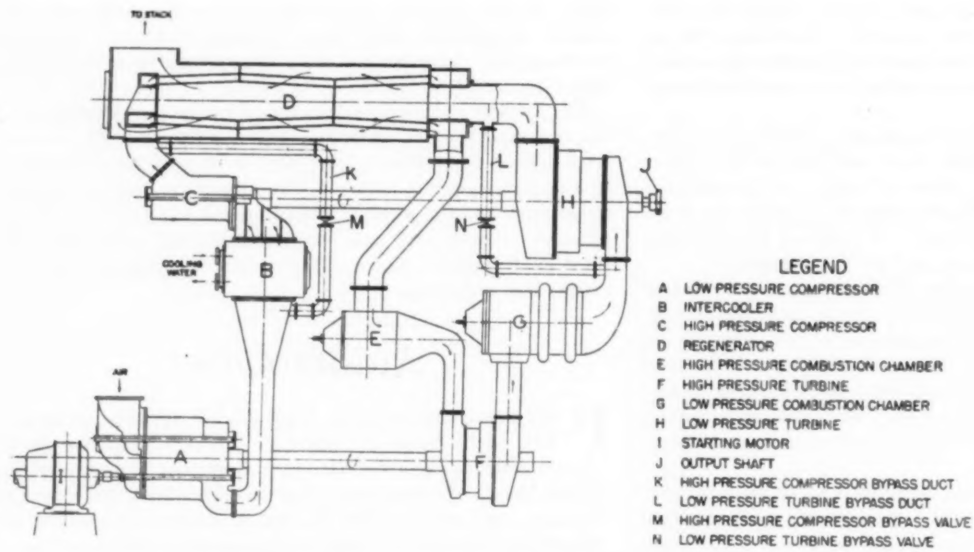

FIG. 4 SCHEMATIC ARRANGEMENT OF THE ELLIOTT-LYSHOLM GAS-TURBINE PLANT

CYCLE

The cycle selected to meet the technical requirements of the installation is shown in Fig. 4. This cycle embodies "a low-pressure compressor *A*, driven by a free-floating high-pressure turbine *F*, and a high-pressure compressor *C*, driven by the low-pressure turbine *H*, from which the useful power is also extracted. After passing through the low-pressure compressor, the air is cooled in the intercooler *B*, recompressed in the high-pressure compressor, and preheated in the regenerator *D*, from which it passes to the high-pressure combustion chamber *E*, and is delivered to the high-pressure turbine. The exhaust from the high-pressure turbine is reheated in the low-pressure combustion chamber *G*, after which it passes to the low-pressure turbine and thence exhausts to the stack by way of the hot side of the regenerator.

"A motor *I*, connected to the low-pressure compressor through an over-running clutch, is used for starting. Partial by-pass ducts *K* and *L* with the valves *M* and *N* serve to isolate the high-pressure turbine and low-pressure compressor during starting."

COMPRESSOR

"The Lysholm compressor is essentially a screw pump with the rotor so designed that the air is compressed within the casing. The low-pressure compressor is a double unit rated at approximately 25,000 cfm at a pressure ratio of 3, while the high-pressure compressor is a single unit with one half this displacement. Identical rotor pairs are employed in all compressors. Clearance between a pair of compressor rotors is maintained by timing gears with the result that the engaging surfaces of the compressor require no lubrication.

"In contrast to other displacement types, the Lysholm compressor is suitable for relatively high speeds of rotation without incurring excessive induction losses. As a result, the effect of clearance leakage is diminished. At the present stage of development, peripheral speeds of about 300 feet per second are possible, providing the compression ratio is two or more. Radial and axial clearances of the order 0.1 per cent of the diameter have been found practical. Inasmuch as the inlet and discharge ports are located on diagonally opposite sides of the casing, it is desirable to equalize the resulting temperature distribution with a water-jacketed casing, if the clearances are to be maintained at a minimum."

CONTROL

The authors explain that the plant is adapted to simple control and that the output is adjusted solely by the regulation of fuel delivery using three actuating levers on the control panel. Pressure and temperature gages, speed indicators, starting controls, as well as miscellaneous warning lights actuated by the safety mechanisms, are also installed on the control panel.

"Under this type of control," they report, "the plant can be maneuvered as rapidly as the load can be followed with the water brake. Maneuvers from very light load to full load in about 15 seconds have been made without trouble. Maneuvers from a full-ahead speed of 3000 rpm to a no-load speed of about 1400 rpm, and thence back to 3000 rpm, have been completed in 90 sec without any signs of distress. In these maneuvers the water-brake setting remained constant and they therefore represent the most severe conditions that can be imposed in land trials without excessive complications."

TESTS

In 1943 when theoretical studies of the cycle used in this plant were made, it was predicted that full-load efficiency of 32 to 33 per cent could be attained. These values, however, were not attained, as actual performance data revealed a full-load efficiency of 29 per cent (based on the low heating value of the fuel) and quarter-load efficiency of 20 per cent. See Fig. 5.

The authors explained that the discrepancy between the theoretical and actual efficiency lay in the gas turbines and the low-pressure compressor. Subsequent study revealed that although the turbine-blade pitches originally selected were satisfactory for steam they proved too large for gas and that by a suitable adjustment of blade pitch, turbine efficiencies in the anticipated range could be developed. It was also found that "by a more informed choice of rotating speed and proper tooling, compressors could be made whose efficiencies meet original expectations."

TROUBLES

As a pioneer development the Elliott-Lysholm gas-turbine plant has not been without its headaches. Some of the troubles have been corrected while others await further development. Originally carbon glands were used in the high-pressure machine but these were found to disintegrate in temperatures about 850 F and were replaced with the step-type labyrinths which functioned satisfactorily.

Temperature stratification at the outlet of the high-pressure combustion chamber has been a serious problem. It is expected that "a more complete control of temperature stratification would be achieved in future combustion chambers by the results of investigations under way on the eddy formations within the chamber proper. No stratification of significance has been observed in the low-pressure combustion chamber."

At the present time a warming up period of $2^1/_2$ to 3 hr is required to place the plant in operation. In future designs

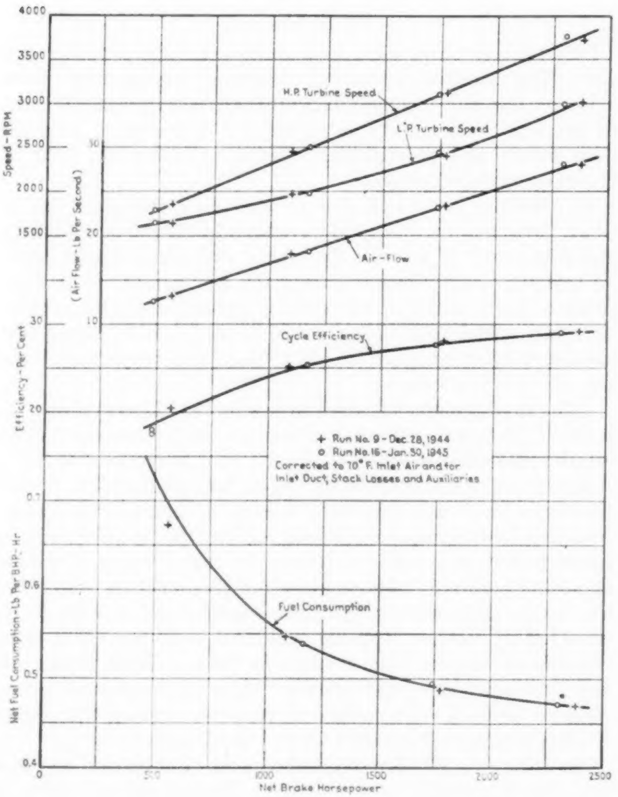

FIG. 5 PERFORMANCE OF THE ELLIOTT 2500-HP GAS-TURBINE PLANT

when more attention is given to thermal expansion, more satisfactory starting characteristics may be developed.

Troubles have been encountered in the maintenance of close clearances, so necessary for the success of the displacement compressors, when foreign materials found their way into the rotors. Objectional noise accompanies the use of displacement compressors and no satisfactory solution has yet been found for this annoyance.

The other miscellaneous mechanical troubles were the same that can always be expected to plague any development of new equipment.

In their concluding statement the authors said, "This development is only the beginning; there are a great many problems to be solved before a gas turbine becomes an established prime mover. With the confidence gained through the successful operation of this plant, there is every reason to expect that these problems will be attacked with vigor and intelligence. The incentive should be even greater, for recent metallurgical developments open new possibilities for advances in operating temperature, with resulting improvements in efficiency and reduction in size. While far from perfect, the Elliott gas turbine has given encouraging results, and it has paved the way for the three additional units now under construction."

DISCUSSION

In the discussion period that followed a brief statement by Professor Soderberg at the Naval Architects' meeting, those speakers whose primary interest lay in the field of development and manufacture commented on the experimental nature of this installation and said that the results were far from pessimistic. Those speakers, on the other hand, whose primary interest lay in the economic use of the gas turbine, while acknowledging that the installation was the first step and could not be compared to steam or Diesel prime movers which had the benefit of years of development, said that the gas turbine before it could be seriously considered on a competitive basis would have to show much progress in three directions: (1) The use of cheap and contaminated fuels such as bunker C fuel oil; (2) considerable reduction in the warming-up period; and (3) the elimination of noise.

When this paper was read before the Annual Meeting of The American Society of Mechanical Engineers it stimulated an active discussion which demonstrated wide interest in the Elliott-Lysholm installation.

Because operating fuel cost of a tanker is 30 per cent of the over-all cost compared to 7 per cent for a cargo ship, the discussion suggested that in the field of tanker operation, the economy and the lightweight of the gas turbine may be looked upon with favor.

The gas turbine, as a new prime mover which raises the sights to higher economies in the power field, serves an important and necessary function. Like every new competitive device it serves to wake up and to advance research in the fields of the traditional prime movers and power systems. The engineer, like every other species of the race, seems to require the fire of competition to advance from one habit of thought to another.

The advent of the Elliott-Lysholm gas turbine marks the first symptom in the break of the traditional conservatism in marine engineering design, and portends a new relationship with stationary practice. The discussion suggested that the time may be near when marine engineers will no longer follow by a span of years the practices ashore but will tend to strike out on their own and give direction to some of the future land innovations.

Propulsion Machinery

THE phenomenal expansion of the American Merchant Marine during the war years provided the stage for a practical test of the quality of contemporary American genius and ingenuity.

That this unusual period of creative effort was beset with special conditions which aggravated the basic problems of construction and operation, was confirmed by Daniel S. Brierley, Director, Division of Maintenance and Repair, United States Maritime Commission, in a paper, "Experience With Merchant Ship Propulsion Machinery in War," presented at the 1945 annual meeting of the Society of Naval Architects and Marine Engineers.

Mr. Brierley's remarks were based upon the operating experience and performance of approximately 87 different types of ships identified by a Maritime Commission design. In a comprehensive review touching on the outstanding difficulties with propulsion machinery during the emergency period, he expressed his purpose as that of setting forth the pertinent and major machinery operating, maintenance, and repair experiences encountered by the merchant fleet during the war period, based on the information available and within the limitations prescribed and without reference to instances involving enemy action or marine casualties.

BOILERS

Boiler care and maintenance suffered considerably because of factors introduced by the war. Passing over routine repairs, Mr. Brierley placed emphasis on the prevalence of bottom-row tube failures on the Liberty type cargo ship. He said, "There has been a prevalence of bottom-row circulating-tube failures in the water-tube boilers on the emergency-type cargo vessels:

These failures have manifested themselves in ruptured blisters and tube deformations, the distortion in some cases being so extreme that the tubes were actually pulled out of the headers on one end."

"It cannot be said," he continued, "that no cases of drastic oil carry-over from the propulsion and auxiliary equipment to the feedwater systems have occurred. However, such cases are in the minority, those involving a gradual and continual admission of oil to the boilers having been more serious. Tube failures classified as being the result of these oil conditions, with the tubes appearing warped and bowed but not ruptured, have been justified where the presence of oil was determined and in the majority of cases responsibility reverted back to faulty operation and improper maintenance."

ECONOMIZERS

During the past four or five years there has been a tendency to favor marine boilers equipped with economizers rather than those equipped with air-heaters. The operating record of the war has revealed "a tremendous number of economizer failures." Referring to economizer performance, Mr. Brierley said, "Rare have been the cases of faulty operation and too numerous have been the cases attributable to design and manufacture.

"Oddly enough the original design of the boilers in question did not provide for feeding other than through the economizers. The foregoing leak sources, coupled with this design feature, have been the outstanding causes for the majority of the economizer repairs requiring element replacement.

"On Jan. 5, 1945, at approximately 2:40 p.m. it was reported that the main turbine failed to respond properly to governor control. The governor valve opened and failed to close and as a result the main turbine increased its speed above normal. Immediately the watch engineer ran into the boiler room to close the main stop. While doing this, the turbine tore itself to pieces. The extent of the major damage that resulted is as follows:

(1) The main turbine was completely carried away; the shaft was buckled and bent; the coupling bolts were torn adrift; the turbine casing was distorted, and the governor mechanism was fragmented.

(2) The main generator shaft carried away at the forward end; the forward bearing and bearing pedestal were in fragments, and the rotor and stator windings were torn and adrift.

(3) The main switchboard was indented and holed from flying fragments.

(4) The main turbine and generator foundations showed indentations and distortion from strain and flying fragments.

(5) The upper rows of tubes in the main condenser were carried away and damaged by flying fragments."

REDUCTION GEARS

One of the most critical bottlenecks of the war, the one responsible for the American renaissance of the use of the triple-expansion steam engine for cargo-vessel propulsion, was the manufacture of reduction gearing. The Maritime Commission, in development and utilizing to the fullest extent every possible source, procured a number of marine-type reduction-gear rotating elements from foreign sources. Commenting on the performance of this equipment, Mr. Brierley said, "Unfortunately the experience encountered in the operation of those vessels equipped with these gears has been most discouraging and unsatisfactory." While there has been no agreement on the cause of the poor showing of foreign manufactured gears, it was decided that all such gears should be taken out of operation.

DIESEL ENGINES

Diesel-driven ships were used quite extensively during the war. The various operating problems experienced were more or less the commonplace difficulties experienced prior to the war. The crankcase explosions, however, because of their nature and peculiarities, tended to widen the field of Diesel operating experience.

Mr. Brierley explained that Diesel-engine crankcase explosions, "while not widespread have been by far the most serious and disastrous of all the operating difficulties encountered on this type of equipment during the war period. Their occurrence has resulted in widespread interest, study, and analysis, both within the industry and without, in a united and unstinted effort to ascertain their cause and to prevent their repetition in the future.

"The first casualty occurred at sea on Feb. 27, 1944," he reported. "At approximately 8:55 a.m. one of the oilers on 8 to 12 watch appeared at the chief engineer's room to report that No. 6 cylinder of the starboard main engine had a severe knock and that he had been sent to call the chief by the engineer on watch. Almost simultaneously with this incident prior to the oiler's return and to the chief's entering the engine room, a terrific explosion occurred. The engineering personnel on watch below at the time, consisting of one engineer and another oiler, managed to escape. Topside personnel were prevented from entering the engine room because of the fire which broke out and surrounded the upper grating. As a result, the emergency controls on deck were utilized to stop the engines, the engine room was isolated, and the CO_2 system released."

According to Mr. Brierley, subsequent examination revealed that No. 6 piston head was cracked through for one third of the circumference at the bottom of "B" ring groove and all ring lands were chipped at the edges. There was also considerable fire damage and the adjacent auxiliaries were extensively damaged by flying parts.

DISCUSSION

Wide interest was shown in Mr. Brierley's account of the performance of wartime marine equipment. All speakers commended the author for his frank revelations and said that it was this spirit of open and frank discussion of difficulties among the members of the engineering profession in America that had given this country its world leadership in the field of technological development.

Of interest was the discussion by Harold J. Chase, General Electric Company, who, in commenting on the author's quotation from the logbook of a vessel which reports complete destruction of the propulsion turbine-generator, said: "While the problem appears to be one of turbine overspeed, it is obvious that the problem arises as the consequence of difficulty in some other part of the system, and further, although the case is recorded as concerning turbine-electric propulsion units, the same situation can exist in the case of ship service generating-set turbines, boiler-feed-pump turbines, or any turbines from which the load may be removed suddenly. Chemical analysis of the samples (found on the valve seats) revealed that the material was composed largely of sea salt, indicating the presence of salt water in the boiler system, together with a degree of carry-over that transferred the salts to the turbine valves. This particular problem has been a product of wartime operation, but may be one that demands correction for peacetime service.

"This is an example of how problems in one element may produce other problems elsewhere in the power plant. The difficulties outlined by the author are worth studying from the standpoint of their effect on related equipment, as well as the apparatus immediately affected."

George A. Mattucci, The Babcock and Wilcox Company, in commenting on the prevalence of bottom-row tube failures in the boilers of the Liberty ship type of cargo vessel, said: "Based on a close follow-up of boilers as installed in ships of this type, we have found that the presence of oil on the internal surfaces is by far the main reason for the bottom-row tube difficulties that have been experienced. That such difficulties can be avoided is proved by the fact that only a small percentage of the total number of these ships have experienced such trouble. On the ships where such difficulty has been experienced and which were investigated and followed up by us we have found that further difficulty was prevented by minimizing the quantity of oil being used for internal lubrication, proper application and supervision of boiler-water treatment, more frequent cleaning of the filtering mediums in the filter tank and grease extractor, and more frequent cleaning and boiling out of the internal boiler surface. The proper attention to these factors should therefore eliminate similar difficulties in the postwar operation of these ships."

Referring to economizer leakage difficulties, Mr. Mattucci said: "It has been our experience in both the marine and stationary field that it is impossible to maintain expanded joints indefinitely tight on economizers under all conditions of operation. Further, when such leakage prevails and is not immediately discovered, severe corrosion conditions have developed from the combined action of the escaping water and the sulphur in the attendant products of combustion. Where such leakage difficulty has been experienced it has always been eliminated by means of seal-welding the tubes to the headers in addition to the usual expanded-type joint."

That seal-welding of economizers had already been carried out in many cases with satisfactory results, was confirmed by Mr. Mattucci, who added that, "the effectiveness of seal-welding as a preventive for economizer-seat leakage was also demonstrated on several prewar installations."

High-Pressure Marine Power Plant

PRIMARILY for the information of marine engineers, Harold F. Robinson, naval architect, and Eugene P. Worthen, chief engineer, Bethlehem Steel Company, presented before the annual meeting of The Society of Naval Architects and Marine Engineers a paper, "The Ore Carrier S.S. *Venore*," which reports in a comprehensive manner the design and performance of a significant example of the art of American marine engineering.

The building of the *Venore* represents the problem of creating a vessel capable of carrying 24,000 tons of cargo at a speed of 16 knots at a fuel rate of a little more than one barrel of oil per nautical mile.

Because the ship was designed and built under wartime conditions, severe limitations were in effect on the availability of high-temperature alloys, on the consideration of any departure from the standard designs of such prime equipment as boilers and turbines, and on the use of piping with thicknesses in excess of "double extra heavy."

Within the framework of these limitations, however, the designers succeeded in creating the first series of nonexperimental 1450-psi geared-turbine-drive ships of which the *Venore* is the second to be completed. In order to attain the high efficiency prescribed, novel features were incorporated in the design of the power plant, the most notable of which are the use of 1450 psi main steam and the use of a double steam reheat cycle.

In view of the 450-psi steam present standard of cargo ships and the 600-psi steam which is the present Navy standard, the use of 1450-psi steam for the main propulsion units was a definite departure from present marine practice. This advance has been encouraged by three years of successful operation of the S.S. *Examiner* built by the Bethlehem Steel Company for the United States Maritime Commission just prior to the war. The purpose of the *Examiner* was to test the practicability of high-pressure steam for marine applications.

While some operational difficulties have been experienced on the *Examiner*, which uses 1200-psi steam and a gas reheat cycle, only part of these difficulties could be attributed to the high-pressure steam, and it was felt that "by proper attention to design details, high-pressure-steam machinery could be made as reliable as the present low-pressure plants."

The successful application of high-pressure-steam machinery for marine service, the authors said, "requires as a first consideration that the ship be suitable for this type of machinery."

A study of high-pressure-steam applications showed that "the power at which the ship will operate most of the time must be in excess of 9000 shp, if a satisfactory high-pressure power plant is to be obtained. Also the ship should be of a type that will benefit economically by the reduction in the fuel rate that can be obtained with high-pressure machinery."

"The S.S. *Venore*," the authors said, "is particularly well suited as the power is high, the voyage long, and the period in port brief. The need for efficient machinery increases with the power and with the length of time which the vessel is at sea, since these conditions increase the ratio of fuel costs to over-all operating expenses. These same factors also require increased reliability of the main propulsion plant, as there is very little time for repairs and the plant must be operated at the designed power for long periods."

STEAM REHEAT CYCLE

Because of the nonavailability of high-temperature alloys, main steam temperatures in excess of 750 F could not be considered. In order to avoid excess moisture in the last stages of the low-pressure turbine and the loss of efficiency and erosion of blading that excess moisture causes, the straight Rankine cycle was out of the question for this application. Some form of reheat was therefore indicated.

The gas reheat cycle was studied and not favored because "with this cycle, a separate reheat furnace is required in order that the gas flow over the reheaters may be shut off when the vessel is going astern and there is no steam flow to the reheater. This is an added complication and requires interlock so that the burners in the reheat furnace will be shut off automatically whenever the turbines are reversed. This cycle also has a very large amount of main steam piping to and from the gas reheaters."

The double steam reheat cycle was therefore selected primarily because of its simplicity of operation and because such marine requirements as quick maneuverability and easy reversibility could be obtained without undesirable complications. This cycle also gave adequate assurance of proper moisture conditions in the low-pressure turbine.

In describing the double reheat cycle, the authors said: "The steam pressure and temperature entering the high-pressure turbine may be the same as for the gas reheat. After leaving the high-pressure-turbine cylinder the steam passes to a steam reheater which is located between the high-pressure and the intermediate-pressure-turbine cylinders. The steam reheater is a heat exchanger with turbine steam flowing outside the tubes and steam at boiler pressure inside the tubes. Turbine steam is superheated to about 20 to 30 degrees below the saturation temperature of the boiler steam, by condensing

the steam at boiler pressure. The drains, so formed, are pumped back to the boiler by special drain pumps. The turbine steam on leaving the (first) steam reheater, passes into the next (intermediate-pressure) turbine cylinder." The steam then passes to the second steam reheater where it is again reheated in a like manner to about 20 to 30 degrees below the saturated temperature of steam at boiler pressure. From this

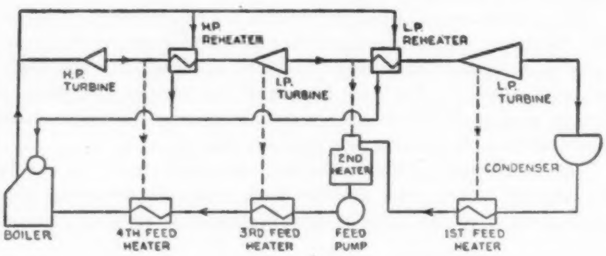

FIG. 6 STEAM-CYCLE FLOW DIAGRAM

point it passes to the low-pressure-turbine cylinder and then to the condenser in the usual manner.

A schematic sketch of this cycle is shown in Fig. 6.

LOW-PRESSURE SERVICE STEAM

"In order to insure the purity of the feed to the high-pressure boilers," the authors continued, "it was decided that steam from these boilers would serve only turbines and heat exchangers in the machinery space and that all steam required for galley, heating system, fuel-oil heating, deck steam machinery, etc., would be from a low-pressure steam plant completely isolated from the main high-pressure plant."

A 125-psi steam system was therefore installed utilizing a large contaminated-water evaporator which uses steam from the main boiler via a reducing valve set at 400 psi gage. The drains from the evaporator coils are returned to the boilers via the deaerating feed tank.

PERFORMANCE ON TRIALS

Trials were conducted in July, 1945. On both trials no difficulties were experienced in running the high-pressure machinery and the vessel was put through all the usual maneuvers without incident.

Fuel-oil economy obtained on the builder's run was very close to the design estimate and on the official three-hour normal power-endurance run, the average oil consumption for all purposes (corrected to 18,500 Btu) was 0.504 lb per shp per hr, or about 1 per cent better than the expected design figure.

DISCUSSION

The general tone of the discussion that followed the authors' brief statement was an expression of thanks for the remarkably complete and detailed exposition of the authors' work. While there was much interest in the high-pressure feature of the *Venore*, some speakers expressed regret that wartime limitations prevented the designers from considering a more progressive use of steam temperature and that so much direct-current electrical machinery and so many deck steam auxiliaries were evident in the design.

Carbon-Metal Friction

NEW approaches to the engineers' struggle against friction were promised by W. E. Campbell, Bell Laboratories, Inc., in his paper, "Factors Influencing the Wear of Carbon Brushes Under High-Altitude Conditions," read before a session of the 1945 A.S.M.E. Annual Meeting sponsored by the Research Committee on Lubrication when he reported the experimental substantiation of the molecular theory of friction.

"There are two general theories for the cause of friction between two rubbing surfaces in close contact with one another," Mr. Campbell said. "The older mechanical theory explains this boundary friction as the resistance to motion brought about by the interlocking irregularities of the surfaces in contact. The newer molecular theory explains boundary friction as the electrical attraction of the molecules in one surface for the molecules in the other rubbing surface.

"Examination by electronic diffraction methods of carbon-metal surfaces after having been in rubbing contact in wet and dry atmospheres, coupled with the various-wear-rate information obtained in experiments, indicate that molecular attractive forces between two rubbing surfaces play an important part in the production of friction.

"Our experiments have also revealed," he continued, "that if rubbing surface of the carbon brush is treated so that the crystals are all lined up in the same direction, exposing a certain crystal facet to the plane of wear, the friction and wear of the rubbing surfaces are very low under conditions which would produce high wear and friction when the crystals are randomly assembled."

Relatively rough surfaces with interlocking irregularities, experiments showed, produced the same wear as highly polished surfaces when there was between them a molecular film of water, but that as soon as the molecular film was removed by changing to a dry atmosphere, the wear increased considerably for both kinds of surface. The wear between relatively rough surfaces and between highly polished surfaces, however, was the same in both atmospheres. Mr. Campbell concluded from these observations that the increase in wear noted when the experiments were run in a dry atmosphere was caused not by any surface irregularities but by the absence of the lubricating molecular film of water.

Mr. Campbell feels his work is the first substantiation of the molecular theory of friction and that the field of crystalline orientation of some of the common bearing metals may prove worthy of study.

New Kaiser Car

KAISER-FRAZER Corporation's entry in the automobile industry—the Kaiser, named for Henry J. Kaiser—will be a full-sized six-passenger automobile with new body lines and the following outstanding features:

(1) It will be the first American car in the low-priced field to have front-wheel drive. The six-cylinder 85-horsepower engine together with the clutch, transmission, and final drive assembly form a single "packaged power unit" forward in a manner which makes it possible for the engine, transmission, and differential to be lifted clear for easy service.

(2) Unlike other types of front-wheel drive made in the United States, the Kaiser engine is placed forward of the front driving axle, thus maintaining a more constant center of gravity and resulting in better traction under all driving conditions.

(3) The Kaiser is the first mass-production passenger car in America to have independent "torsionetic suspension" on all four wheels. Twisting action of heat-treated steel bars gives new smoothness of ride at all passenger loads. Hydraulic shock absorbers complete this unique assembly.

(4) Body and chassis form a single unit of the type known as "monocoque" construction, eliminating strain, shifting between body and frame, and body squeaks.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Grease Lubrication of Ball-Bearing Motors and Generators

Comment by W. T. Everitt[1]

An examination of the "consistency versus temperature chart" of bearing greases in the paper by E. M. Higgins[2] reveals some interesting information. We could say that there is no general all-purpose grease. Grease No. 2 shows good worked-penetration characteristics between —40 to 0 C, while grease No. 4 has approximately the same penetration range from 20 to 100 C.

The writer merely wishes to point out that the conditions and temperatures of operation fit certain greases for a general range of applications. For example, if the vast majority of motors operated in an ambient temperature of 20 to 40 C, it is rather unprofitable to search for a grease that will also satisfy the few motors located outside the building, where the temperature may occasionally reach —40 C. It appears as though it would be better to have greases to cover the majority of motors operating within certain ranges and carry a few specialties for unusual conditions.

For engineers who are unfamiliar with the A.S.T.M. penetration range it might be well to correlate it with Nos. 1, 2, and 3 cup grease, whose consistency almost every engineer knows.

Comment by W. G. Forbes[3]

Upon reading this paper the writer was reminded of the case of a large company which had about 80,000 to 100,000 ball and roller bearings in their factories, and their records showed that only one bearing had failed as a result of faulty lubrication during the course of a year. But in the meantime they had replaced 8000 bearings during the same year! So the other 7999 had just worn out from natural causes. This type of naïve reasoning is not unusual in the field of lubrication; on the contrary it is quite common.

The author also brings out a point that is not often clear to many users of grease, namely, that a melting point of 400 F does not mean the grease can be used in surroundings of this order; it simply means that the grease will stand a high temperature for a few moments without running out of the bearing. This characteristic is extremely useful in steel mills where hot slabs of steel may stop for a few moments on the conveyer roller. High-melting-point greases are also adapted to operating temperatures above 180 F, but they are not adapted to continuous service at their melting-point rating.

The author has outlined everything anybody needs to know about lubricating antifriction bearings on motors and generators. This might seem a simple matter, but experience shows that such is not the case, and the paper therefore has considerable value, particularly for maintenance engineers who often have charge of several hundred and even thousands of these machines.

Comment by H. A. McConville[4]

This paper covers a large variety of factors which play a part in successful grease lubrication. With such a wide scope, only a brief treatment of each subject can be given. It would seem desirable at a later date to elaborate on the many points brought out. There is not too good agreement on the proper selection of greases between engineers or lubrication men. One desires a hard grease, another a soft one for the same purpose. At present, there is no means of evaluating which type is most desirable. How heavy can a grease be and still provide sufficient lubrication? The author answers this by inferring that if a grease bleeds sufficient oil to provide lubrication, it could be quite stiff. But what is a satisfactory rate of bleeding? That is something yet to be determined, possibly at some time by Technical Committee G on Lubricating Greases of A.S.T.M.

In our company we have used the pressure-relief system of greasing over a period of years and find it very satisfactory; in fact, it is the only way to lubricate satisfactorily a large number of motors, many of which are in inaccessible places and cannot be readily disassembled to be cleaned and relubricated. We cannot stress too highly the troubles that come from overgreasing of bearings. Many complaints have been traced back to that source, and overheated bearings will usually cool down when the excess grease is removed.

Greases for high- and low-temperature lubrication are subjects of intensive study at the present time. Experience gained today will be of value for the needs of the future. If management could only see the wisdom of employing a higher class of man to lubricate their plant machinery, it is the writer's opinion that they would be well repaid. Every large company could save money by entrusting its lubrication problems to a lubrication engineer. This paper should be valuable in calling attention of engineers and management to the possibilities in this field.

Comment by C. L. Pope[5]

Great care must be exercised in judging a grease-performance test. This is especially true where bearing failures are involved as it is difficult to judge which is cause and which is effect. Soap deposits or oxidized grease can easily break a bearing retainer or spin the outer race in the housing causing bearing failure; or a broken retainer, overloaded bearing (overload may be induced in mounting bearing), or an outer race spinning may cause conditions which will prematurely cause oil-soap separation or oxidized deposits.

Fig. 1 of this comment shows an inner race of a ball bearing that failed after a very short run, and it was alleged that the grease might be responsible as the grease was partially oxidized, some soap deposits and of course considerable metal was found. It will be noted that this bear-

[1] Eastman Kodak Company, Rochester, N. Y.

[2] "Grease Lubrication of Ball-Bearing Motors and Generators," by E. M. Higgins, Mechanical Engineering, vol. 67, 1945, pp. 639–644 and 669.

[3] Lubrication Engineer, Tidewater Associated Oil Co., New York, N. Y. Deceased.

[4] Schenectady Works Laboratory, General Electric Company, Schenectady, N. Y.

[5] Lubrication Engineer, Eastman Kodak Company, Rochester, N. Y. Mem. A.S.M.E.

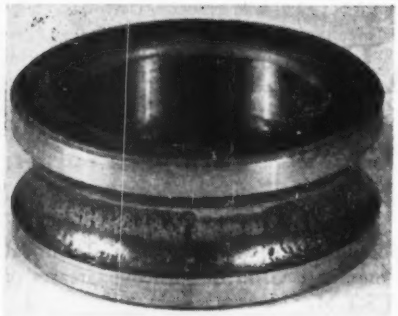

FIG. 1 INNER RACE OF BALL BEARING THAT FAILED

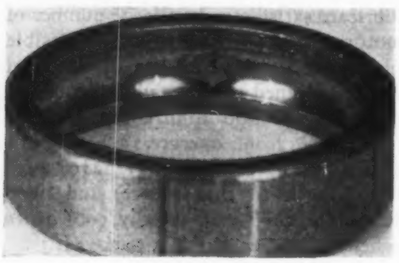

FIG. 2 OUTER RACE THAT WAS PINCHED OUT OF ROUND IN A SPLIT-BEARING HOUSING

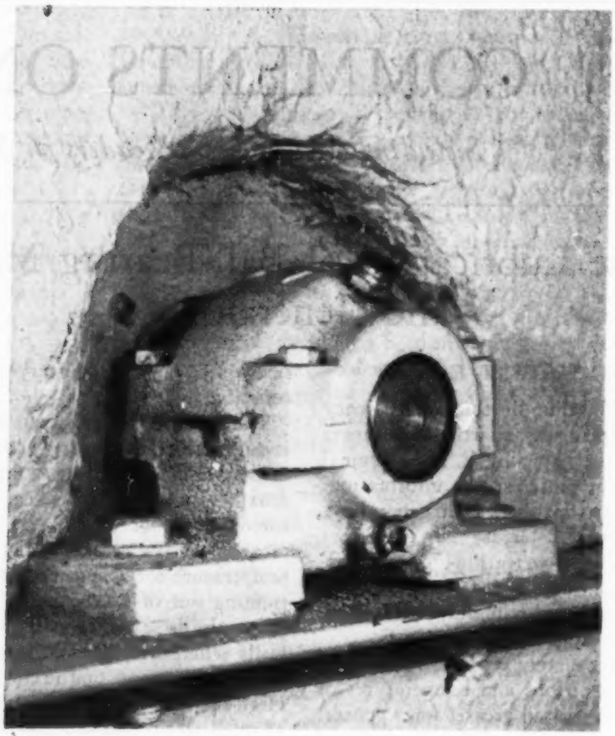

FIG. 3 FAN BEARING USED FOR TEST PURPOSES

ing failed from excessive thrust as the wear track is from the center of the race to one edge. This thrust could be accounted for only by a faulty assembly. Fig. 2 shows an outer race that was pinched out of round in a split-bearing housing in which the wrong thickness of gasket was used. One of the fatigue spots can be seen and the other was 180 deg from it. One can evaluate grease performance only by judging average performance over many installations.

In testing greases in equipment, we have never lost a bearing that we know of due to grease failure, by making our first inspection after 3 months of continuous running. If the grease has shown no changes, inspection periods are lengthened to 6 months or a year, depending on the severity of the service. On test, four greases out of eleven ran 36 months of continuous duty on pump motors with no addition to the grease.

Fig. 3 shows a fan bearing selected for test because of accessibility and ease of inspection. This bearing has run 37 months continuously at time of photographing. Note absence of grease leakage.

COMMENT BY C. N. BENSON[6]

The author's approach to this highly controversial subject is not only practical but highly instructive as well. Good lubricant and proper maintenance are low-cost insurance against loss of production. It is hoped that this paper will reach those who buy just grease and apply it on a hit-or-miss basis.

To obtain a suitable lubricant for ordinary operating conditions presents no problem since there are many good greases available today. The procurement of a good grease, however, is not the entire answer to good lubrication. The amount and the way it is applied are equally as important. The author has dealt with this phase of the problem at quite some length and here again it is hoped that the user of antifriction bearings will take heed and benefit from his timely remarks.

AUTHOR'S CLOSURE

As Mr. Everitt points out, there is no "general all-purpose" grease for ball-bearing motors and generators. The "general-purpose" grease is indicated for the vast majority of cases, and it is necessary to use highly specialized greases for temperature extremes. One large motor manufacturer made a survey of this some time ago and the findings were as noted by Mr. Everitt. Over 95 per cent of industrial motors are operated where a good general-purpose grease is satisfactory.

Comparisons of A.S.T.M. worked penetrations with commercial cup-grease consistencies were published in 1942, by the National Lubricating Grease Institute as follows:

Consistency	Worked penetration
0	355–385
1	310–340
2	265–295
3	220–250
4	175–205
5	130–160
6	85–115

Mr. Forbes can be complimented in bringing to light a situation, that of "naïve reasoning" in the field of lubrication, something we are all too often up against. In doing so he has performed a real service for us all.

We appreciate the many-sided problems confronting the plant engineer, the mechanical superintendent, or the master mechanic, each with a program of expansion and alterations, a routine calendar for repair work, and the ever-present breakdown that requires immediate attention. They cannot personally supervise the application of lubricants, and the pressure of other work often forces lubrication maintenance to the bottom of their work list.

They do not have time to train men fully for this work and must use unskilled help; yet it is their responsibility. Management, because of the expense in-

[6] Engineering Department, SKF Industries, Inc., Philadelphia, Pa. Mem. A.S.M.E.

volved, will not allow them to use better men.

Unfortunately, lubrication maintenance has not been placed on the high plane where it belongs; only in a few outstanding places will one see the startling results that can be secured. We have too many untrained men pouring or pumping buckshot into expensive equipment and not even crossing their fingers. This may sound exaggerated but many of us have seen this happen.

Postwar competition, with manufacturing costs being carefully watched, will call for increased attention to a program of preventive maintenance.

The plant-lubrication survey chart made by outside lubrication engineers is very helpful but the technique of application is not written into these instructions. The chart is only a helpful guide.

As Mr. McConville points out, the problem of plant lubrication is of major importance. It warrants the services of a lubrication engineer who lives on the job and gives his time and energies to its study.

Technical schools should give this subject greater recognition by providing comprehensive courses on the subject. Untold savings in the operation of industrial plants would result.

As Mr. McConville states, there is diversified opinion among engineers as to the desirable consistency for a general-purpose ball-bearing lubricant. Research in grease lubrication is interesting because of the very fact that so many variables have to be considered in choosing a satisfactory product, consistency being only one of the variables.

Experience has taught us that stiff greases have caused many bearing failures for reasons outlined in this paper. Greases which bleed excessively, increasing the soap ratio in the grease pack, offer similar inadequate lubricating films eventually. Inspections have shown heavy greases or greases which have lost oil too fast without any discoloration from the initial amber color on both sides of the bearing, none of the grease ever having worked at all. The small amount of grease in the bearing will be found jet-black due to overworking of the film, from iron pickup due to borderline lubrication and oxidation.

The entirely unworked and undiscolored hard grease pack on both sides of the bearing might as well be in a can near the motor for all the lubrication value it offers the bearing.

The theory offered that slight bleeding is highly desirable is not meant to convey the thought that slight bleeding itself from even a stiff grease takes care of the problem. This would not satisfy the lubricant demand of a bearing. Slight bleeding is an accessory which provides a softer outer layer of grease held in suspension on the bearing sides of the grease pack, giving the grease ability to feed itself slowly into the bearing as a lighter-consistency material, having a worked penetration of from 320 to 350, not as a straight oil. The grease pack itself in the meantime should not churn, as this would provide the setup for a fluid-friction temperature rise.

The softer outer layer is not an immediate condition in the grease pack after greasing but is a slowly developed phenomenon, advancing with the demand of the bearing for more lubrication.

The suggested range of 250 to 300 penetration is on the softer side and this range could even be narrowed to 275 to 300.

Mr. Pope brings up an interesting phase whereby many failures are charged to the lubricant, whereas mechanical difficulties are to blame. This is always an easy way out in placing responsibility for bearing trouble. He also strongly brings out the point that it takes a long time to judge the true value of a lubricant and makes his tests in the best known possible way, long-period actual operation, with periodic observation.

Bearing failures that can be traced to incompetent lubricants may not occur quickly, many greases will keep a bearing running. Mr. Forbes points out a good example where high replacements were charged to natural fatigue. An attempt has been made in this paper to point to that angle particularly. The bearing might be "running" but, at the same time, slowly wearing out or building up deposits. Then there is the oily leakage from many greases which in ordinary terms, mess up a motor so that premature thorough overhaul and cleaning is the only way to keep the unit in operating condition electrically.

E. M. HIGGINS.[7]

[7] Master Lubricants Company, Philadelphia, Pa. Mem. A.S.M.E.

Operating Experience With Gas Turbines

COMMENT BY J. H. ANDERSON[8]

The record of performance attained by the gas-turbine units described in this paper[9] has been satisfactory enough to justify the place of the gas turbine in the field of the process industries and to forecast its increased application in the future.

To supplement details of the paper, information is requested on the following points:

While Kingsbury or tapered-land thrust bearings are commonly preferred to ball bearings for this class of machinery in the United States, it would be interesting to learn whether the ball bearings themselves are blamed for the failures encountered, or whether the variations in thrust due to load changes were greater than expected when the machines were designed.

In this connection it is the writer's understanding that the turbine and compressor thrusts at least partially balance each other through a solid coupling.

Does the available power output of the units decrease noticeably with time because of increased seal leakage, dirt, erosion, etc.?

[8] Ingersoll-Rand Company, New York, N. Y. Mem. A.S.M.E.

[9] "Operating Experience With the Gas Turbine," by A. E. Pew, Jr., MECHANICAL ENGINEERING, 1945, pp. 594-598.

COMMENT BY PAUL R. SIDLER[10]

It is gratifying to see this report on the operation of several gas-turbine sets following the Brown Boveri design, and particularly to read the conclusion that these machines have proved eminently satisfactory. The Sun Oil Company is, of course, in a favorable position to assemble such data and to make them available to a wider group of engineers, as it has had such units in operation since the latter part of 1936.

In looking over some of the tabulations and conclusions it is noticed that Table 2 of the paper lists 7 units whereas in Tables 6 and 8 only 6 units are tabulated. In these last two tables the 40,000-cfm unit at Toledo appears to be missing and one wonders why.

Table 6 shows a total of 4507 operating days for the first two Brown Boveri units which were built in Switzerland, and a total of 4751 operating days for four sets built by Allis-Chalmers, according to Brown Boveri designs. The average time out for the two Brown Boveri units is 1.48 per cent of the total time, while for the four Allis-Chalmers units the average is 1.88. It is fully agreed that both factors are quite satisfactory, but it is particularly gratifying to the writer that the two machines built

[10] Resident Engineer, Brown, Boveri & Company, Ltd., New York, N. Y. Mem. A.S.M.E.

in Switzerland and operating under American conditions have behaved even somewhat better than the American-built units.

A service-demand availability factor of 95 is generally considered as good for steam turbines. This factor is 98.5 per cent for the first two gas-turbine sets of Table 6, and it will be agreed that this shows indeed a high measure of reliability.

Fig. 4 of the paper shows the arrangement of the combustion chamber used for starting these units, and it is stated that this design is an adaptation by Sun Oil engineers from the basic Brown Boveri design. This is the first indication that Brown Boveri designs had been used in such combustion chambers—evidently with success—and comes as an agreeable surprise to the writer, who would of course be interested in further particulars.

In conclusion, it is hoped that this valuable paper will induce others to publish actual data on the operation and maintenance of gas-turbine sets. This type of information will go far toward reassuring prospective users of gas turbines as to their inherent ability to show at least equally gratifying results as the steam turbine.

AUTHOR'S CLOSURE

The pressure drop through the system from compressor outlet to turbine inlet was somewhat greater than originally anticipated. This in turn resulted in higher thrust toward the turbine than was expected and led to a more rugged design of axial ball thrust bearing. Difficulties still existed, however, resulting in failures from such causes as not obtaining perfect lubrication of the balls, chipping and pitting of the balls, and breakage of ball races.

In answer to Mr. Sidler's comments, data from the Toledo unit were not available at the time the paper was presented. The Toledo installation to October 31, 1945, had operated 2194 days and had been down eleven days or 0.5 per cent of its total days on account of turbo trouble.

If Mr. Sidler will recall the days of our first turbocompressor unit he will no doubt remember that a pressure burner for starting the turbine and heating up the cases was furnished by Brown, Boveri and Company. This was installed in a combustion chamber having an inner and an outer shell.

A. E. PEW.[11]

[11] Vice-President, Manufacturing Department, Sun Oil Company, Philadelphia, Pa.

An American Society of Engineers

TO THE EDITOR:

It is encouraging to see articles of the type written by Professor Faires and published in the November issue of MECHANICAL ENGINEERING. Few would disagree that there is an urgent need for engineering to become a unified profession, rather than to attempt to function through the efforts of the separate societies, as is now the case.

We should like to offer a few comments on the plan proposed by Professor Faires. We feel that he has rendered a real service by bringing this vital question to the fore, and wholeheartedly support his motive. However, we feel that some of the specific points proposed are open to discussion.

Items 4 and 5 suggest that the associated societies would pay dues to the A.S.E. for each of their members, and at the same time retain their present dues schedules. We doubt that this could or would be done. The Founder's Societies are making very little progress concerning many of the functions of the proposed A.S.E. Therefore we feel that increased service desired by many engineers will entail some increase in present dues.

The last sentence of item 6 states that members of associated societies who do not qualify as engineers would not be eligible for membership in the A.S.E. By what criteria are we going to determine who qualifies as an engineer? Item 8 states that A.S.E. membership would be open to engineers not now members of any engineering society. Again, what critiera are to be used? This item (8) proposes that an engineering degree be the requirement for membership in the A.S.E. In our opinion this is entirely inadequate. We personally know men with engineering degrees who never had any intention of being engineers. In some instances men took postgraduate courses in business administration, law, medicine, etc. Others went directly into business not even related to engineering. Furthermore, many never rose above the rank of draftsman or other routine work of a subprofessional nature. Therefore, it seems that qualification should be on some other basis. Such other basis does exist in the State Examining Boards for Engineers. It is true that State License Acts need improvement in some instances, but we feel that legal registration is the correct basis, and that all engineers should give their support to raising registration standards.

In regard to item 7, would the member belonging to two or more associated societies be the one who indicates which shall pay his A.S.E. fee? Further, if he discontinued one of his associated society memberships, what confusion might arise as a result?

It seems to us that item 11 may result in an extremely unwieldy organization at best. In addition, we fail to see how an associated society could be prevented from seceding, as mentioned in item 15, since the union would be formed under voluntary conditions.

It therefore appears that a separate organization dealing exclusively with professional aspects of engineering might be able to act more firmly and speedily than a Federation of existing societies. Such an organization need not conflict with present societies, whose support could be given without prejudice to the interests of their membership.

In reference to collective bargaining, we do not believe that the Wagner Act would permit an organization whose membership is open to both employer and employee to act as a bargaining unit.

In conclusion, we would like to reiterate that we are heartily in favor of one society to represent all engineers in professional, legislative, civic, and economic matters. Our criticisms have been constructive in their intent, as we sincerely hope to see a satisfactory solution.

W. A. HINTON.[12]
E. S. THEISS.[13]
RALPH E. LEWIS.[14]
FREDERICK J. REED.[15]
VAN KENYON, JR.[16]
T. C. COOKE.[17]

TO THE EDITOR:

I have just read the artlcle "An American Society of Engineers (A.S.E.)" by Virgil M. Faires in the November, 1945, issue of MECHANICAL ENGINEERING, and feel that Mr. Faires has made a proposal which justifies definite action by the A.S.M.E.

The issue has, of course been considered by various groups of engineers from time

[12] College of Engineering, Duke University, Durham, N. C. Mem. A.S.M.E.
[13] Duke University, Durham, N. C. Jun. A.S.M.E.
[14] Duke University, Durham, N. C. Mem. A.S.M.E.
[15] Duke University, Durham, N. C. Mem. A.S.M.E.
[16] Duke University, Durham, N. C. Mem. A.S.M.E.
[17] Engineer, Tomlinson, Co., Inc., Durham, N. C. Mem. A.S.M.E.

to time. About a week ago, in fact, when I attended an A.S.M.E. section meeting at Spokane, Washington, a discussion developed regarding an engineers' organization of a type such as the A.S.E. The discussion arose following a talk by the guest speaker in which he expressed the opinion that engineers had failed to gain recognition for themselves because of the backstage nature of their work and because of the lack of a national organization of sufficient power and prestige to acquaint the people of this country with the vital functions which the engineers perform. I am not advocating an agency solely for publicity purposes; however, it does strike me that engineers, as professional people, should certainly have the opportunity of belonging to a professional organization capable of representing engineers as a group.

There are innumerable other reasons why we should have an A.S.E.: For example, the engineer's pride in his profession, better and more frequent local meetings, closer co-operation and co-ordination of activities with engineering schools, standardization-committee activities, better understanding of engineering practices among all engineers, etc. There are, too, disadvantages to an A.S.E.; however, these are apparently minor in comparison to the many advantages to be gained.

The organization as proposed by Mr. Faires may not be exactly as sought by many engineers, but it is definitely along the right lines. Then too, the specific methods of organization can best be handled by a committee.

I agree, furthermore, with Mr. Faires, "that a strong engineering society will be the only means to combat successfully the unionization of engineers."

WICKLIFFE B. HENDRY.[18]

[18] Captain, Air Corps, U.S.A. Jun. A.S.M.E.

Fundamentals in Engineering Education

TO THE EDITOR:

Although I have had the honor of lecturing at various times in two of our largest institutions of learning, I have never been a member of the teaching profession. However, I have always been interested in efforts to broaden education and to place it on a more rational basis.

Certainly the world would experience a gain, if all education were broader and included a real introduction to economics, philosophy, and history. Some time given to the social sciences would give us engineers better prepared for executive positions and men who would be of more constructive service to their communities.

Inclusion of more subjects in the college curriculum would call either for more years of study or for more efficient courses of study. Is it not possible that chemistry, physics, mechanics, thermodynamics, and mathematics might be taught as a single complex subject, rather than as unrelated branches of knowledge?

Under the present system, a group of pedantic professors can make the sciences unrelated stagnant brain puddles, and even in a single branch, such as physics, a dry professor can make it the study of separate branches of natural phenomena such as light, heat, sound, and mechanics, each one to be mastered in turn on a parrot basis and remembered as separate entities, at least until examination time.

Actually, chemistry and physics merge into one science, mechanics joins the party as part of physics, and thermodynamics exists only as related to the two main subjects. Mathematics is the tool which can be used as a language to explain our research, as an instrument to perfect our processes, as a rational check on our theories, and as a crystal ball to explore regions beyond the range of our physical instruments.

Considerable work would be required to develop the course of study for the new complex subject. A possible approach would be one which would automatically give emphasis to the now neglected atomic and nuclear items. We might start with the building materials of the universe and with its basic power. Conservation of mass and energy would be taught from the fundamental concept that, where one seems to be destroyed, it appears as the other. The student would learn the structure of the elements before he attempted the structure of substances. He would learn to predict valences from atom structure rather than learn them as mysterious attributes. The intricate formulas of the calculus would be linked with the actual problems as the need for higher mathematics developed. Instruction and experimental work would supply the detail of the student's knowledge, but he would be constantly trained to use his powers of analogy to gain breadth of understanding.

Physics and chemistry would be taught in this manner up to the point where specialization begins and our mechanical, electrical, and mining engineers would be furnished with the elementary atomic and nuclear knowledge now reserved for the physicist and the advanced chemical engineer.

Such elementary atomic knowledge is already needed by the modern engineer. This is clearly indicated by examining some of the recent engineering reports. For instance, in Technical Note 989 of The National Advisory Committee for Aeronautics, R. C. Rinker and G. M. Kline, of the National Bureau of Standards, present a paper on "The Theoretical Aspects of Adhesion." The subject is developed under the headings, Electrostatic or Polar Bonds, Covalent Bonds, Metallic Bonds, Van der Waal's Forces, The Chemical Properties of Surfaces, and Determination of Adhesion by the Bartell Cell. Most of these headings deal with forces originating in and determined by the atomic structure of the substances under consideration. An engineer must know some "atomic engineering" to fully appreciate papers of this type.

H. LESLIE BULLOCK.[19]

[19] Director, Bullock-Smith Associates, New York, N. Y. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published herewith with corresponding paragraph number to identify their location in the various sections of the code

and are submitted for criticism and approval from anyone interested therein.

It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N.Y., in order that they may be presented to the Committee for consideration.

PARS. P-2(**e**) and U-13(**k**). Add the following:

Materials outside the limits of thickness given in the title or scope clause of any specification in Section II of the Code may be used if the material is in compliance with the other requirements of the specification, and no similar restriction is given in the rules for construction.

PARS. P-103 and U-71. Revise first sentence to read:

The materials used in the fabrication of any fusion welded drum, shell, PIPE, or parts covered by this Code and, etc.

Add the following:

(**d**) A combination of two materials of different specifications may be made by fusion welding providing the requirements of Par. Q-101 are complied with.

TABLES P-5, P-7, and U-2. Delete the classification and stresses for "fusion-welded" under "pipe and tubes."

PARS. P-108(**a**) and U-76(**b**). Add the following.

Several vessels of varied thicknesses may be stress-relieved in the same furnace at the same time. The test plate need not necessarily be stress-relieved with the vessel and it need not be held at the specified temperature for a period greater than required on the basis of one hour per inch of thickness of the test plate, but in no case for a materially longer period than the drum itself.

PAR. P-186(**c**). Revise first two sentences to read.

Fusion welding may be used in the fabrication of doorholes provided the sheets are stayed around the opening in accordance with the following:

(1) If both sheets are flanged, the distance from the points of tangency of the flanges and their respective sheets to the center line of the staybolts shall not exceed the permissible pitch as specified in Par. P-199;

(2) If either or both sheets are not flanged, the distance from the root of any weld to the center line of the staybolts does not exceed one half the permissible pitch as specified in Par. P-199.

The fit up of the several parts of a fusion welded door opening shall be such that the maximum gap between the two plates to be joined by welding shall not exceed $^1/_8$ in.

PAR. P-300. Add the following to the first sentence of the fifth paragraph:

a fabricator in possession of the Code symbol stamp for piping shown in Fig. P-41 and who has been issued a Certificate of Authorization.

PAR. P-332(**c**). Add the following to the first sentence:

who is in possession of a Code symbol stamp (See Fig. P-47) and a valid Certificate of Authorization

Add as a new third paragraph of (**c**):

In addition to the above, permission to use the symbol is limited to the period of time specified on the Certificate of Authorization.

Add as the fourth paragraph of (**c**):

Any manufacturer complying with the foregoing provisions will be issued or reissued a Certificate of Authorization to use the symbol for a period of three years upon payment of an administrative fee. The Certificate shall include the date of issue and date of expiration, and be signed by the chairman and secretary of the Boiler Code Committee. The Society reserves the right to cancel or not to reissue the Certificate any time upon failure of a manufacturer to comply with the provisions of the agreement under which the symbol was issued by notification and return of the current fee.

In the fourth paragraph of (**d**) add the following sentence:

The manufacturer in signing each data report shall state under his signature the expiration date on the Certificate of Authorization to use the symbol.

DATA REPORTS. Add a line after the one used by the manufacturer for signature reading: "Certificate of Authorization expires........ 19....."

TABLES P-7 and U-2. Add a reference to Specification SA-129 under "Plate Steels," with a specified minimum tensile of 44,000 psi, allowable working stress of 8800 psi for temperatures not exceeding —20 to 650 F.

PAR. Q-101(**b**). Add the following as PO19:

PO19 A change from two similar base materials to two having different O or P numbers.[2]

A.S.T.M. Specifications A 193-44T. To be included in Section II of the Code as Specification SA-193.

PAR. L-116. Add the following:

L-116 Reinforcement of Openings for Firebox Syphons. In locomotive fireboxes, with or without combustion chambers, which are equipped with staybolted syphons, the openings in the crown sheet should be reinforced as outlined below:

(1) If more than 40 per cent and not more than 50 per cent of the total length of the crown sheet is removed, not less than 10 per cent of the removed longitudinal ligament shall be restored;

(2) If more than 50 per cent and not more than 60 per cent of the total length of the crown sheet is removed, not less than 20 per cent of the removed longitudinal ligament shall be restored;

(3) If more than 60 per cent and not more than 70 per cent of the total length of the crown sheet is removed, not less than 30 per cent of the removed longitudinal ligament shall be restored;

(4) If more than 70 per cent of the total length of the crown sheet is removed, not less than 40 per cent of the removed longitudinal ligament shall be restored.

PAR. U-2(**a**). Revise by changing the words "rupture disks may be used in lieu of safety valves" to read "rupture disks may be used in lieu of or in combination with safety valves (see Par. U-10)." Add the following:

Stop valves may be placed between pressure relieving devices and the vessel protected thereby, if these stop valves are so constructed or controlled that the closing of the maximum number of outlets possible at one time will not reduce the pressure relieving capacity provided by the unaffected outlets below the required relieving capacity.

PAR. U-2. Insert the following as Par. U-2 (**b**), relettering the other sections:

(**b**) Pilot valve control or other indirect operation of relief valves is not permitted in lieu of a spring-loaded safety valve.

PAR. U-3(**c**). Change reference to "U-10(**b**)" to "U-10(**c**)." Substitute the present note by the following:

NOTE: When a rupture disk is to be used as the relief device in lieu of or in series with a safety valve, it is suggested that the maximum allowable working pressure of the vessel be sufficiently above the intended operating pressure to provide sufficient margin between operating pressure and rupture disk bursting pressure to prevent premature failure of rupture disk due to fatigue or creep.

PAR. U-10(**b**). Add the following as Par. U-10(**b**), changing present (**b**) to (**c**):

(**b**) A rupture disk may be installed on the outlet side[1] of a spring-loaded safety valve which is opened by direct action of the pressure in the vessel and is so constructed that it will not fail to open at its proper pressure setting regardless of any back-pressure that can accumulate between the valve disk and the rupture disk; and further provided:

(1) The valve is ample in capacity to meet the requirements of Par. U-2;

[1] This use of a rupture disk in series with the safety valve is permitted to minimize the loss by leakage through the valve of valuable, noxious or otherwise hazardous materials, and where a rupture disk alone or located underneath a safety valve is impracticable. A rupture disk may be used between the safety valve and the discharge outlet only where contents of the vessel are clean fluids, free from gumming or clogging matter, such that accumulation in the space between the valve inlet and the rupture disk (or in any alternate outlet that may be provided) will not clog the outlet. This arrangement shall be restricted to services where atmospheric temperatures are not exceeded.

[2] Where there is a marked difference in the flexibility of the metals being joined, the free-bend test may be replaced by a test procedure that will produce a bend similar to that obtained by the use of a guided-bend test jig, as shown in Fig. Q-19, with the weld approximately in the center of the bend; or the soundness of the weld may be determined by any other form of test that will reveal the completeness of penetration and fusion.

(2) The disk is designed to rupture at not more than the allowable working pressure of the vessel;

(3) The opening provided through the disk, after rupture, is sufficient to permit a flow equal to the rated capacity of the attached safety valve;

(4) Any piping beyond the disk cannot be obstructed by the ruptured disk or fragments;

(5) All valve parts subject to stress due to the pressure from the vessel and all fittings up to the rupture disk shall be designed for not less than the allowable working pressure of the vessel;

(6) Any small leakage or a larger flow through a break in the operating mechanism that may result in back-pressure accumulation within enclosed spaces of the valve housing so as to hinder the safety valve from opening at its set pressure, shall be relieved adequately through vent openings provided to atmosphere.

NOTE: When a rupture disk is installed on the outlet of a safety valve fitted with a lifting device, a valved vent shall be located between the valve disk and the rupture disk to permit checking the operative condition of the safety valve. The distance between the safety valve and the rupture disk shall be a practical minimum.

Users are warned that replacing a rupture disk on the outlet of a safety valve may be attended by some danger if done without first reducing the pressure in the vessel, particularly when noxious or otherwise hazardous contents might be discharged.

PAR. U-13(c). Revise to read:

(c) Fusion-welded vessels over 1 in. in thickness constructed of steel conforming to Specifications SA-202 Grade A, SA-203, SA-204, SA-212, and SA-225 shall conform to the provisions of Par. U-68. Where vessels constructed of these steels do not exceed 1 in. in thickness at any welded joint, the provisions of Par. U-69 may be followed provided:

(1) All vessels are stress-relieved except those constructed of Specification SA-212 material. Stress-relieving of vessels built of SA-212 material shall be governed by the provisions of Par. U-76(b);

(2) The steels conforming to Specifications SA-203, SA-204, SA-212, and SA-225 are of firebox quality.

PAR. U-36(a) Add the following as the definition for E:

E = lowest efficiency of any joint used in forming the head which is not coincident with a diameter. (This does not apply to the joint attaching the head to the shell.)

PAR. U-62(a). Revise to read:

(a) Vessels subject to external corrosion shall be so installed that there is sufficient access to all parts of the exterior to permit proper inspection of the exterior, unless adequate protection against corrosion is provided, or when the vessel is of such size and is so connected that it may readily be removed from its permanent location for inspection. Vessels having manholes, handholes, or cover plates to permit inspection of the interior shall be so installed that these openings are accessible. In the case of vertical cylindrical vessels subject to corrosion, the bottom head, if dished, must have the pressure on the concave side to insure complete drainage.

PAR. U-68(e). Revise the elongation requirement to read:

Elongation, minimum, per cent, in 2 in. =

$$20 \text{ or } = \frac{700{,}000}{U} + 10, \text{ WHICHEVER BE LESS}$$

where U = minimum specified tensile strength of the material to be welded, psi, as given in Table U-2.

PAR. U-68(f). Revise the last sentence of the first paragraph to read:

The specimen shall be bent [cold] under free bending conditions until the least elongation measured within or across approximately the entire weld on the outside fibers of the bend-test specimen is 30 per cent OR EQUALS $\frac{700{,}000}{U}$ + 20 per cent, WHICHEVER BE LESS.

PAR. U-76(b) Delete the words "unless otherwise limited by the provisions of Par. U-13(c)."

PAR. U-208(e) Replace items (1) and (3) by:

(e) Retests. (1) Spot Examination. When a spot has been examined and the welding does not comply with the minimum quality requirements referred to in (b) for radiographing or in (c) for sectioning, additional spots shall be examined by either method in every seam not previously examined on which the same operator has welded, to the number and at locations as shall be determined by the inspector. Based on such examinations the inspector shall decide on the extent of local repairs or the need for the rewelding of all seams on which that operator has welded. Sectioning specimens meeting minimum quality requirements may be replaced by weld metal, if, in the inspector's opinion, they are not so closely spaced that excessive residual stresses may result; otherwise the affected length of seam shall be completely rewelded. All rewelded areas shall be re-examined, as required by the inspector, and shall comply with the minimum quality requirements.

Annulled Cases

The following Cases have been annulled as they are no longer needed, most of them having been formulated as emergency war measures:

Cases Nos. 931, 943, 947, 957, 959, 978, 1000, 1004, and 1015.

This action was taken by the Boiler Code Committee at its meeting on Dec. 7, 1945, and approved by Council on Jan. 10, 1946.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Industrial Plastics

INDUSTRIAL PLASTICS. By Herbert R. Simonds. Third Edition. Pitman Publishing Corporation, New York, N. Y., 1945. Cloth, 6 × 9 in., 396 pp., illus., $5.

REVIEWED BY FRANK W. REINHART[1]

THIS book is a general treatise on the technology of plastics. The topics considered include an introduction, basic materials, ten important plastics, molding practice, fabrication, physical properties, plastics and metals, equipment and plant, industrial applications, other plastics, and borderline materials, design, future, foreign practice, chemistry of plastics and a list of trade names. The material in the book is not well organized.

However, the most disturbing features are the mis-statements, omissions of important facts, and the lack of specifying units in some cases. Thus, on page 18 it is stated that "a plastic part is a part that is pliable." Is the molded phenolic plastic on your toaster plug pliable? In a list of accelerators for curing phenolic resins one of the most widely used, hexamethylenetetramine, is not mentioned. The values for Young's modulus for a laminated plastic are given as 1,200,000 to 2,000,000 with no units indicated on page 118. On page 159 the modulus of elasticity is defined as the "quotient obtained by dividing the stress per square

[1] Organic Plastics Section, National Bureau of Standards, Washington, D. C.

inch by elongation in 1 inch in length caused by the stress" and the values given for all types of plastics, one of which is the laminated phenolics, vary from 2 to 15. Those familiar with what the modulus of elasticity is will recognize the fallacy in the definition. Many of those seeking a knowledge of plastics will get the wrong concept concerning the modulus of elasticity as well as the magnitude of the values for plastics. Certainly, if the uninitiated were to compare the values given on page 159 with those for other materials given in various handbooks, they would get a decided misconception concerning plastics. Although these errors and omissions are few, they are inexcusable for the third edition of a book on a highly technical subject.

Human Leadership in Industry, the Challenge of Tomorrow

HUMAN LEADERSHIP IN INDUSTRY, THE CHALLENGE OF TOMORROW. By Sam A. Lewisohn. Harper and Brothers, New York, N. Y., 1945. Cloth, $4^7/_8 \times 8$ in., 112 pp., $2.

REVIEWED BY A. R. STEVENSON, JR.[2]

THE Committee on Education and training for the Industries of The American Society of Mechanical Engineers selected Training for Leadership as the theme for its sessions at the 1945 Annual Meeting. Many of the members may have attended the luncheon and meeting on this subject on Nov. 26, 1945, at the Hotel Pennsylvania. Mr. Lewisohn's book is therefore particularly opportune. It is the best treatise on the subject which I have read, and it is so interestingly written that I have no hesitation in recommending it to my friends.

In one of his opening sentences Mr. Lewisohn says that in most cases the labor problem has been approached in a spirit of emotional intensity rather than rational analysis. He cites the need for idealism in handling matters of this kind, noting that we have had tragic evidence in recent history that the absence of idealism makes possible an over-estimation of power at the expense of humanity.

Mr. Lewisohn points out that state socialism is no cure for discontent. He makes the interesting statement that "only in a static one (society), as among the Incas at one period of their history, was there an absence of restlessness . . ."

Discontent is not due to the capitalistic system. The author points out that in government departments there is discontent which has resulted in the formation of unions of government employees. He mentions, in passing, that the frequency rate of accidents in 1943 for the DuPont Corporation was one fifth the accident rate in government departments such as Commerce, Post Office, Federal Works Agency, and Agriculture. He says, "The civil service, the police department, the school system, and other institutions not based upon the profit motive have their labor problems . . ."

Some people blame present evils on the large corporations. Mr. Lewisohn points out; "Intense bitterness often existed between the employees and the owners of small, family-owned plants in England and in Germany. . . . It is certain that the worst exploitation today and some of the most troublesome forms of unrest are associated with small-scale sweatshop industry, where boss and wage earner work side by side. Indeed, one of the chief complaints of various branches of the clothing industries in New York has been that where the units are too small the unions can do little to check evasion of standard terms of employment . . ."

Having pointed out the lack of foundation for some of these popular fallacies, Mr. Lewisohn leads up to a whole series of statements to the effect that leadership is the most important criterion for the success of any co-operative undertaking, saying, "For leadership is behind all the dynamics of production. Without leadership, co-operation would be tepid and barren of results." He goes on to say that whenever there is a difficulty, the primary deficiency is probably in the personality of the leader, i.e., "If he is equipped emotionally and intellectually to lead wisely, the industrial situation is likely to be good. If he is biased, ignorant, or neglectful in the matter of human organization, there is liable to be an unhealthy condition . . . . Impatient to get results, executives forget that in adding machines the response is automatic but that from human beings co-operation must be developed . . . . Labor's co-operation in these matters largely depends on management's persuasiveness, leadership, and understanding of the human element involved . . . . There is a close relationship between the degree of co-operation and effectiveness shown by employees and the leadership capacity of the employer. This has been demonstrated in numerous cases, but I was most impressed with it in an instance of a large company that had a score of similar departments. These had been rated from, let us say, one to twenty in the amount and quality of their results. An experiment was then tried in shifting executives so that those who had formerly had the best records were put in the so-called worst departments, and vice versa. Two complete shifts were made, and in each case the result was that in time the men who had been leading before brought their new units to the top; on the other hand, the executives who had had the worst records before the experiment was started, ended up in approximately the same relative position in spite of the previous performance of their subordinates . . ."

Mr. Lewisohn points out that professional personnel men make good staff officers but that the real responsibility for good labor relations depends on the operating managers. He says:

In these days of largely corporate proprietorship, the owners of mines are guided in their relations with labor by engineers occupying executive positions. On them falls the responsibility in such matters, and the engineer becomes thus a buffer between labor and capital . . . The question is: what preparation have they had to act as such a buffer: A background limited to physics, chemistry, mathematics, mechanics, and other specific sciences does not equip a man to act as a "buffer between labor and capital." Some engineer executives who are absorbed and effective in the technical problems of management neglect those which may be termed the "political" aspects. They have a distaste for the inexact "art" of handling human beings and ignore it for the sake of problems more intellectually fascinating to them. But for their present responsibilities some training in psychological problems and the mental attitudes of men, some knowledge of modern sociological tendencies, some grasp of the incentives that make men act, some acquaintance with the purposes of trade-unions and the art of collective bargaining, and some understanding of the techniques of human engineering are indispensable . . . . In the educational process there has been a disproportionate emphasis upon formal preparatory training as compared with that upon the education acquired while on the job. But in any branch of human activity or knowledge the training received while we are still immature leaves a superficial impression as compared with the experience of active life. Hence the problem of training embryo managers, the executives of the future, is only one aspect of the question. There is left the problem of making it possible for those who become actively engaged in any undertaking to continue to acquire new knowledge and to interpret new experience.

He quotes Graham Wallas as dividing people into two classifications: Those

[2] Staff Assistant to Vice-President in Charge of Engineering Policy, General Electric Company, Schenectady, N. Y. Fellow A.S.M.E.

who desire to lead and those who desire to be led. He then plunges into a most important problem: How can labor be brought to appreciate its long-run stake in increasing production?

Management's assumption of sole responsibility for productive efficiency actually prevents the attainment of maximum output . . . . Workers have a passion for efficiency, detest needless wastes, and love to work in an orderly shop, mill, or mine where production flows smoothly. Where these conditions do not prevail, workers are full of ideas on how they can be brought about or, where they do prevail, how they can be improved.

Why don't they come out with their thoughts? What's holding them back? . . . . The problem, then, is to create the kind of relations between management and organized workers that bring about an interchange of ideas and suggestions on how to increase efficiency, eliminate waste, and otherwise reduce costs.

When employers recognize the vital need of developing opportunities for labor to co-operate in production, unions will more widely assume the role predicted for them by their friends.

Unions, with their array of leadership and talents, will become a potent force in national productiveness. Hence the resourceful, socially responsible employer regards it as part of his professional duty to develop constructive methods of co-operation with unions. He regards it as a real opportunity in social experimentation.

Earlier in the book Mr. Lewisohn pointed out that one can go too far in attempting to let labor share the responsibilities of management.

No self-governing workshop, no trade union, no professional association, no co-operative society, and no local authority—and no office or industrial enterprise belonging to any of these—has yet made its administration successful on the lines of letting the subordinate employees elect or dismiss the executive officers or managers whose directions these particular groups of employees have, in their work, to obey.

He asserts that the public wants more goods for more people at less cost and these can be obtained only by efficiency in industry. By way of comparison he points out that "in political life in a democracy, the goal of efficiency must to no small extent be sacrificed for the sake of individual self-determination . . ."

He sums this up in the following paragraphs:

What are the main things for which society is striving in the industrial system—a system certainly as important to man as the political structure? I think we can safely say there are two main objectives, namely, the greatest possible production and the maximum development of each human being. We want production, but not in a way that will cripple the human beings in the system orally, emotionally, or physically. We want the self-development of the human being, but not at the cost of retarding production too greatly.

It is sometimes useful to make a purely tentative classification as a framework for discussion. In this spirit, what in broad terms are the concepts that should guide an executive in dealing with his workers? I should roughly classify the more important desires of the workman as the desire for *justice*, the desire for *status*, the desire to have *his job made a career*, and the desire for *security*.

In the same spirit, in a plant, justice must be enforced in this clear-cut manner even against an official.

The necessity of giving individuals a sense that they are regarded as of some consequence and are appreciated was illustrated by an experiment with a selected sample group jointly conducted by the Western Electric Company and the Industrial Research Department of the Harvard Graduate School of Business Administration on the matter of fatigue.

Important to the maintenance of sound industrial relations is the adoption of a policy by management of sharing with employees directly the information which should make them understand the economic and business problems faced by the enterprise. Without in any way by-passing union officers or established procedure for conferring through them, there are certain direct channels of communication which the employer should enlarge. This should be done in a straightforward manner.

For example, one method would be to publish company reports understandable to employees and other concrete material in company magazines. The subject matter which should be discussed may range from broad questions of economics affecting industry generally to specific business problems which the company faces. The success of such talks will depend on the tact and frankness of the employer and the obvious intent to co-operate with the union.

Books Received in Library

AIRCRAFT YEAR BOOK for 1945, 27th annual edition, Howard Mingos, editor, official publication of Aeronautical Chamber of Commerce of America, Inc., Lanciar Publishers, Inc., New York, N. Y., 1945. Cloth, $5^1/_2 \times 9$ in., 688 pp., illus., diagrams, tables, $6. This Year Book, sponsored by the Aeronautical Chamber of Commerce, provides a review of important events in aviation during the last year. The work of the Army and Navy, the development of airports and airways, progress in equipment, and other matters of interest are discussed. Statistics and directories of aviation organizations, manufacturers, and government agencies are included.

TESTING MACHINE TOOLS. By G. Schlesinger. Fourth edition. Machinery Publishing Company, Ltd., London & Brighton, England; Industrial Press, New York, N. Y., 1945. Fabrikoid, $8^1/_2 \times 11$ in., 94 pp., illus., diagrams, charts, tables, $4. This book is intended to guide the machine builder in making and assembling his machines, and to provide the user with a standard of accuracy for the acceptance of a machine. The tolerances specified in the book have been widely accepted in Europe and to a large extent, in this country. Test instructions and specifications are given covering milling and gear-cutting machines, lathes and vertical boring mills, grinding machines, drilling and horizontal boring machines, planers, shapers, slotters, punching presses, and stamping machines. This edition has been revised and extended.

THEORY OF FUNCTIONS, Part 1, Elements of the General Theory of Analytic Functions. By K. Knopp, translated by F. Bagemihl. Dover Publications, New York, N. Y., 1945. Cloth, 4×7 in., 146 pp., diagrams, tables, $1.25. This is the first volume of a translation of Dr. Knopp's well-known monograph on the theory of functions. It is devoted to the fundamentals of the theory of functions of a complex variable: Basic concepts, integral theorems, series, and the expansion of analytic functions in series, singularities. There is a brief bibliography

TOP-MANAGEMENT PLANNING, Methods Needed for Postwar Orientation of Industrial Companies. By E. H. Hempel. Harper & Brothers, New York, N. Y., and London, England, 1945. Cloth, $5^1/_2 \times 8^3/_4$ in., 414 pp., illus., diagrams, charts, maps, woodcuts, tables, $4.50. Top-management planning is considered as that which evaluates and integrates all aspects of an industrial enterprise from a long-range viewpoint. The basic considerations are dealt with in five sections: planning the size of an enterprise; product planning; process planning; machine planning; plant location, activity area, and plant planning. Reconversion problems present a very good example of a situation needing top-management planning.

WORKSHOP YEARBOOK AND PRODUCTION ENGINEERING MANUAL (1), edited by H. C. Town. Paul Elek, Ltd., London, England, 1945. Cloth, $5^1/_2 \times 8^3/_4$ in., 542 pp., illus., diagrams, charts, tables, 30s. Part 1 of this volume, which continues the series previously entitled "Machine Shop Yearbook," contains five articles on special topics. Part 2 presents technical information and descriptions of new equipment under fourteen headings such as: Precision measuring instruments, welding, hydraulic equipment, power transmission, and the standard metal-cutting processes. Part 3 contains some fifty long abstracts from the current technical press dealing with metals and heat-treatment, particularly electrical, and with plastics and powder metallurgy.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

A.S.M.E. 1946 Spring Meeting in Chattanooga, Tenn., April 1 to 3

THE Spring Meeting of the A.S.M.E. will be held at Chattanooga, Tenn., Monday, Tuesday, and Wednesday April 1 to 3 with the East Tennessee Section acting as host. Because of the current housing problem, joint headquarters will be at Hotel Patten and Read House. The regional administrative committee meetings of Region No. IV will be held Saturday and Sunday, March 30 and 31, in Hotel Patten. This will be the first of the regional administrative-committee meetings under the plan of the new constitution.

Chattanooga is the home of the East Tennessee Section whose 168 members comprise the second largest of the ten sections of A.S.M.E. Region IV. With its 411 manufacturing plants making more than 1500 diversified products such as textiles, furniture, machinery, medicines, and leather, Chattanooga is one of the principal industrial cities of the South. As the geographic center of the Tennessee Valley Authority, Chattanooga has the advantage of low-priced hydraulic power which is widely used by commercial and industrial concerns. In the heart of the industrial South which played a significant part in the production of war material, the Spring Meeting is expected to call attention to the contributions and the potentials of the South as well as to its problems.

Technical Sessions to Cover Wide Field

Plans for the meeting are in charge of Roscoe W. Morton, professor of mechanical engineering, University of Tennessee, Knoxville, Tenn. Ten sessions have been requested by the divisions. These include aviation, heat transfer, hydraulics, management, power, process industries, petroleum process industries, and railroads. All members are encouraged to submit suggestions for speakers or subjects that they recommend for considerations for the Spring Meeting program. These should be forthcoming promptly in order to be effective.

Because of the continuing housing problems it was not possible to have all sessions held in one hotel. The Society was fortunate to engage the facilities of Hotel Patten and the Read House, both of which are conveniently situated in the downtown area of Chattanooga within walking distance of one another. Spring comes early in the South and in Chattanooga spring is one of the most beautiful seasons. The commuting problem created by the joint headquarters it is hoped will prove to be a pleasant interlude between technical sessions.

Make Reservations Now

Hotel management of both the Hotel Patten and the Read House are prepared to accept reservations now. Of interest to those who favor the palate may be the noted kitchen of Hotel Patten. The Read House excells in its accommodations. Members are encouraged to make such reservations as soon as they decide to attend the meeting, for it is often easier to cancel a reservation than it is to make one at a late date. In asking for a reservation, mention should be made that it is in connection with the A.S.M.E. Spring Meeting.

THE CHICKAMAUGA DAM FORMING 59-MILE LAKE CHICKAMAUGA AT CHATTANOOGA

Metropolitan Section Night

PLANS for the Annual Metropolitan Section Night sponsored by the Metropolitan Section are fast being finalized. This gala event is one of the high lights of the season and will take place in the Auditorium of the Engineering Societies Building, 29 West 39th Street, New York, N. Y. Keep the date *February* 25 open and plan to attend Metropolitan Section Night and hear Prof. R. M. Sutton of Haverford College, who will talk and present experiments in his own inimitable style on the subject of "From Stars to Atoms and Back Home the Same Night." This lively topic, when discussed as only Professor Sutton can, is sure to be a most interesting and informative evening. A catered buffet supper with all the trimmings will be served prior to the "show."

A.S.M.E. Members Honored by A.S.C.E.

HONORARY membership in the American Society of Civil Engineers was conferred on Charles F. Kettering, member A.S.M.E., Boris A. Bakhmeteff, member A.S.M.E., and Charles H. Purcell during the ninety-third annual meeting of the A.S.C.E. held in the Hotel Commodore, New York, N. Y., Jan. 16 to 19, 1946.

Mr. Kettering, vice-president, General Motors, Inc., is the inventor of the first cash register, the self-starter, four-wheel brakes for automobiles, and many other improvements. Dr. Bakhmeteff, once Russian ambassador to the United States from the Kerenski-government, is professor of civil engineering at Columbia University and a well-known New York City consulting engineer. Mr. Purcell is director of California's state department of public works and chief engineer of the San Francisco Bay Bridge.

Colonel Clarence E. Davies, Secretary A.S.M.E., Receives Legion of Merit Medal

COLONEL Clarence E. Davies, national secretary of The American Society of Mechanical Engineers, was awarded the medal of the Legion of Merit in Washington, D. C., January 8, 1946, for meritorious service while on active duty with the Ordnance Department of the United States Army. The medal was presented by Lieutenant General Levin H. Campbell, Jr., honorary member A.S.M.E., Chief of Ordnance.

The citation read: "Citation of Legion of Merit—Colonel Clarence E. Davies, 0-134089, Ordnance Department, Army of the United States, demonstrated remarkable initiative as Chief, Control Division, Office of the Chief of Ordnance, from June, 1942, to November, 1945. Through his extensive engineering and production experience, able administration, and continual analysis of ordnance requirements, he successfully contributed to the efficient expansion of the Ordnance Department to a wartime basis."

The Legion of Merit Medal recognizes "extraordinary fidelity and essential service" in a position of responsibility, and is conferred on "outstanding officers and enlisted men of the Armed Forces of the United States or of friendly nations." It is the second highest award given to service forces, being next to the Distinguished Service Medal. The Secretary of War announced establishment of the Legion of Merit in 1942.

As chief of the Control Division, Office of the Chief of Ordnance, Colonel Davies was concerned with problems of policy, organization, methods, procedures, and statistical reporting practices for the Ordnance Department. With his experience as associate editor, managing editor, assistant secretary, executive secretary, and since 1934 as national secretary of The American Society of Mechanical Engineers, he was admirably equipped for his duties in the Armed Forces.

GENERAL L. H. CAMPBELL, JR., LEFT, AND COLONEL C. E. DAVIES RECIPIENT OF THE LEGION OF MERIT AWARD

Statistical Control Course to Be Given at Purdue Feb. 19 to Mar. 1

A TEN-DAY course in "Quality Control by Statistical Methods" will be given for control supervisors, industrial engineers, production engineers, design engineers, and persons in charge of specifications for material, Feb. 19 to Mar. 1, 1946, at Purdue University, Lafayette, Ind.

Major topics, such as statistical tools and concepts, frequency table averages and variability, fraction defective, and number of defects will be discussed by leaders in the field of statistical control.

Carl G. Schmid, member A.S.M.E., Naval Ordnance Plant, Indianapolis, Ind., will be on the teaching staff.

Inquiries about the course should be directed to the Technical Extension Division, Purdue University, Lafayette, Ind.

Midwest Power Conference to Be Held in Chicago, April 3 to 5

THE Midwest Power Conference sponsored by the Illinois Institute of Technology will be held in Chicago, April 3, 4, and 5, 1946. Twenty-eight leaders in the field of power in the United States will discuss such subjects as peacetime application of atomic energy, gas turbines, radar equipment, and the citizenship and civic responsibilities of the engineering profession.

P. W. Swain, member A.S.M.E., editor of *Power*, will talk on the peacetime applications of atomic energy in the power field. John T. Rettaliata, member A.S.M.E., department of mechanical engineering, Illinois Institute of Technology; L. N. Rowley, member A.S.M.E., managing editor, *Power;* J. B. Carlson, member A.S.M.E., Westinghouse Electric Corporation; and B. G. A. Skrotzki, member A.S.M.E., will take part in a session of the gas turbine.

Roy V. Wright, past-president and honorary member, A.S.M.E., Simmons-Boardman Publishing Company; A. A. Potter, past-president and honorary member, A.S.M.E., dean of engineering, Purdue University; S. R. Harrell, Acme Evans Company; and F. A. Faville, Faville-LeVally Company, will take part in a symposium on "Citizenship and Civic Responsibilities."

P. S. Dickey, member A.S.M.E., chief engineer, Bailey Meter Company, will present the paper "Automatic Control of Steam Generators and Auxiliaries."

Other papers will cover modernization of small plants, smoke-abatement problems, new developments in coal atomization, radiant heating, and the problems of electrical power supply for steel plants.

Course on Management of Research at N.Y.U.

RECOGNIZING the continuing need for men trained in the field of industrial research and development, the graduate division, College of Engineering, New York University, is repeating this year the graduate course, management of research and development. The course consists of 15 lectures given by distinguished directors of leading companies.

Some of the lectures to be given will be: The Philosophy and Application of Industrial Research, The Qualifications, Training, Aptitudes and Attitudes of Personnel, Selling Industrial Research to Management, and Research in Small Business.

1946 Membership List

March 1 Last Date for Correct Listing

CARDS have recently been mailed to all members of the Society giving them an opportunity to supply correct information for the new Membership List. The cards must be returned by March 1 to insure correct listing.

The new directory will include alphabetical and geographical lists of all those whose dues for the fiscal year beginning October 1, 1944, have been paid in full by March 1, 1946.

With the Membership List information card is another card requesting information for the A.S.M.E. records concerning the "Manhattan Project" and other World War II service.

President's Page

Aid to Libraries in Devastated Countries

ONE of the misfortunes which has befallen engineers and educational institutions in foreign countries has been the destruction of technical books and magazines. Fortunately, however, there is now developing an opportunity by which engineers in this country may be of help. Our Committee on International Relations, of which Past-President Robert M. Gates is chairman, is now appealing for contributions of technical books and magazines and donations in money, in order that war-devastated libraries may be replenished. Urgent requests from abroad have already been received by this committee.

Engineers who have technical books and periodicals to contribute to foreign libraries are urged to send at once to the A.S.M.E., attention of George A. Stetson, Editor, a list of such material and, in addition to the title, the author, publisher, and date of publication of each volume.

Please do not send the books themselves until you have received shipping instructions from the committee, as the destination points may vary with location of the contributors and of the libraries to which they are to be sent.

Money is also needed for the purchase of new books for libraries which do not have adequate financial resources. Please draw checks to the order of the A.S.M.E. and mark "For the International Book Fund."

The committee is working on an attractive bookplate which will be used to mark each book with the name of the engineer who contributes it. By personalizing each book in this way it is hoped to promote international good will within the engineering profession.

In this issue of MECHANICAL ENGINEERING, page 185, will be found a detailed announcement of the plan, which gives the names of the complete committee and also advisory members.

From our abundance of technical literature may our response be generous and prompt.

D. ROBERT YARNALL, *President*, A.S.M.E.

A.S.M.E. Forms Machine Design Group

RECOGNIZING the ever-increasing importance of the field of design, The American Society of Mechanical Engineers has sponsored the formation of a Machine Design Group. Organized primarily for the presentation of technical papers of interest to machine designers generally, rather than to any specific branch of industry, the new group may later assume the status of a full-fledged professional division should interest continue to increase among A.S.M.E. members and others active in design.

Chairman of the group is J. F. Downie Smith, head of the engineering department at United Shoe Machinery Corporation, Research Division, Beverly, Mass., the secretary being B. P. Graves, director of design, Brown & Sharpe Manufacturing Company, Providence, R. I. Plans are under way for a machine-design session at the semi-annual meeting of the Society in Detroit next June, and consideration is being given to the scheduling of joint sessions with other professional divisions where desirable.

Meetings to be held under the auspices of the new group should offer much interest to designers in connection with the technical discussions as well as the opportunities to meet with other engineers having closely allied interests.

JETEC to Be Co-Ordinating Factor in Electronics

THE phenomenal growth of the electronic industry is reflected in the decision of the National Electrical Manufacturers Association and the Radio Manufacturers Association to establish a Joint Electron-Tube Engineering Council for the purpose of co-ordinating all engineering matters relating to electron tubes.

The Joint Council, organized last winter, consists of six men. They are L. G. Hector, D. D. Knowles, O. W. Pike, A. Senauke, G. R. Shaw, and R. M. Wise. Eleven working committees, seven of which deal with individual classes of tubes, and four others which treat such matters as sampling procedures, packaging, type designations, and mechanical standards, assist the Council through the chairman.

The broad general policies and methods of financing the activities of the new JETEC are subject to approval by the Boards of the two associations headed by A. C. Streamer, president of the National Electrical Manufacturers-Association, and W. R. G. Baker, vice-president in charge of the Radio Manufacturers Association engineering department.

Because electron tubes do not recognize trade association boundaries and are as happy when working in radio equipment as they are in an intricate piece of industrial control equipment, the two associations long recognized the advantages of joint effort. JETEC is expected to replace overlapping committees with their wasteful duplication of effort as well as make possible common action on the same committee by the best men of both associations.

Since its organization early in 1945, JETEC has devoted most of its time to war problems of standardization and tube interchangeability. The council is already well along with a big postwar program that is expected to prove a beneficial contribution to the growth of the electronic field.

A.S.A. Annual Luncheon Held in New York, Dec. 27

THE American Standards Association held its 27th annual luncheon meeting on Dec. 7, 1945, at the Hotel Biltmore, New York, N. Y.

Dr. Lyman J. Briggs, retiring director of the National Bureau of Standards, as guest speaker, spoke on "The Impact of War on Science." Mr. Briggs compared the state of science during each of the three wars during his 47 years of public service and enumerated many of the scientific achievements that had been attained.

Referring to advancement in medicine, he said, "These precious achievements of medical science would have come to us in times of peace but the impact of war accelerated their development tremendously and they are now available to every physician."

Henry B. Bryans, executive vice-president, Philadelphia Electric Company, Philadelphia, Pa., who was re-elected for the third time as president of the American Standards Association, in the president's annual address informed the members that the A.S.A. was ready to prove that individual enterprise under democratic procedures could produce results superior to those possible under government direction.

Prizes for Papers on Resistance Welding Offered Totaling $2000

FIVE prizes amounting to a total of $2000 are being offered by the Resistance Welder Manufacturers' Association for outstanding papers dealing with resistance welding subjects. Three prizes are offered to engineers in industry, in consulting work, or in private or government laboratories, for papers concerned specifically with resistance welding. These amount to $750 for the best paper, $500 for the next best, and $250 for the third best paper.

Two prizes are offered to engineers in the field of education, either instructor, student, or research fellow for papers which in the opinion of the Board of Awards are judged the greatest original contribution to the advancement and use of resistance welding. The first prize will be $500 and the second prize will be $200.

The contest, which will close on July 31, 1946, is open to anyone in the United States, U. S. possessions, Canada, and to all members of the American Welding Society, regardless of country of residence. The contest judges will be appointed by the American Welding Society and the awards will be made at the 1946 Fall Meeting of the Society.

American Welding Society Establishes Undergraduate Award

A NEW award known as the A. F. Davis Undergraduate Welding Award has been established by the American Welding Society. The award, funds for which were donated by A. F. Davis, Lincoln Electric Company, Cleveland, Ohio, will consist of four cash prizes totaling $700 and will be presented annually, as follows: $200 each to the author and publication for the best article on welding published in an undergraduate magazine or paper during the preceding year, and $150 to the author and publication of the second best article.

As long as the paper is published in an undergraduate magazine, any undergraduate of a college, university, or institute of technology in the United States and Canada is eligible for the award. Winning papers will be selected in July of each year by the Educational Committee of the American Welding Society.

Civil Engineers Elect Officers for 1946

ON the eve of their ninety-third annual meeting held Jan. 16 to 19, 1946, at the Hotel Commodore, New York, N. Y., the American Society of Civil Engineers announced that W. W. Horner, consulting engineer, St. Louis, Mo., was elected president for 1946.

The A.S.C.E. is the oldest of the American engineering groups and has a membership of more than 20,000.

Arthur W. Harrington, district engineer, U. S. Geological Survey, Albany, N. Y., and J. T. L. McNew, Agricultural and Mechanical College of Texas, were elected vice-presidents.

The following directors were elected: Shortridge Hardesty, consulting engineer, New York, N. Y.; Irving V. A. Huie, Board of Water Supply, New York, N. Y.; Albert Haertlein, professor of civil engineering, Harvard University, Cambridge, Mass.; William R. Glidden, bridge engineer, Virginia State Highway Department, Richmond, Va.; William McKinney Piatt, consulting engineer, Durham, N. C.; and Frederick W. Panhorst, bridge engineer, State Division of Highways, Sacramento, Calif.

Book on Welded Steel Structures Announced by A.W.S.

THE American Welding Society has announced the publication of "The Practical Design of Welded Steel Structures," by H. M. Priest. Within its 150 pages the book contains brief yet adequate discussion of the various welding processes, specifications for electrodes, types of welds, welding positions, qualification tests, and inspections.

The book is bound in cloth, sells for $1 per copy, and can be obtained from the American Welding Society, 33 West 39th Street, New York, N. Y.

Frederick B. Llewellyn Elected President of I.R.A.

DR. FREDERICK B. LLEWELLYN, consulting engineer, Bell Telephone Laboratories, has been elected president of the Institute of Radio Engineers, as announced by the Board of Directors of that society.

Dr. Llewellyn is an international authority on vacuum and has been instrumental in the invention of the ultra-high-frequency oscilator tube which is fundamental in the development of radar. He is a graduate of Stevens Institute of Technology. In 1936 Dr. Llewellyn received the Morris Liebman Memorial prize for his analysis of reactions within the vacuum tube.

Institute of Aeronautics to Be Established by Northwestern University

AN Institute of Aeronautics will be established on the downtown campus of Northwestern University, Evanston, Ill., according to Franklyn B. Snyder, president of Northwestern University. The Institute will require an ultimate endowment of 10 million dollars and will conduct research in co-operation with the American aviation industry on such problems as aviation fuels, power equipment, economics of air transportation, air law, aviation, and medicine.

Fred D. Fagg, Jr., vice-president and dean of faculties, Northwestern University, has been appointed director of the Institute and Paul E. Klopsteg, director of research, Technological Institute, has been appointed associate director.

1946 A.S.M.E. Committee Personnel List Sent on Request

MEMBERS of The American Society of Mechanical Engineers who wish to receive a copy of the 1946 issue of the Society Records containing committee personnel are requested to fill out and mail the accompanying form, or order by letter, addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York 18, N. Y.

This issue, to be published in February, will form a part of the Society Records Section of the Transactions as bound for library use.

A.S.M.E., 29 West 39th St.
New York 18, N. Y.

Please send me a copy of the February, 1946, issue of the Society Records.

NAME..............................

ADDRESS..............................

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A.S.M.E. Railroad Division Holds Notable Annual Meeting

About 300 Railroad and Supply Engineers Attend the Technical Sessions on Solid Fuels, Locomotives, Cars

FOR a number of years the Railroad Division of The American Society of Mechanical Engineers has been steadily increasing in membership and attendance at annual meetings, the technical and practical value of which has also shown constant improvement. The 1945 session, held during the Annual Meeting of the Society at New York on Nov. 28 and 29, was no exception to this rule and brought out a maximum attendance of at least 300 railway and supply-company engineers at the technical sessions and 600 at the annual luncheon.

Under the leadership of chairman W. M. Sheehan, vice-president of the General Steel Castings Corporation, the work of the Railroad Division during 1945, although handicapped by inability to hold a meeting at Chicago in June as planned, culminated in Annual Meeting sessions that were characterized by some as the best arranged and most constructive ever held by the division. One of the features of the year's work was continued effective co-operation with other divisions of the A.S.M.E., such as the Oil and Gas Power, Fuels, and Applied Mechanics divisions, which permitted railway engineers to profit by acquaintance and exchange of ideas with leading engineers in other specialized fields who have much to offer in support of railway progress.

The program of the two-day sessions at New York was an unusually full one. An executive and general committee meeting, expanded to include the chairman and members of other committees, was held on the morning of November 29 to transact necessary business of the division. The meeting was followed in the afternoon by a joint session with the Fuels Division on the subject, "Utilization of Solid Fuels in Railroad Motive Power." The symposium speakers on this subject included K. A. Browne, research consultant, Chesapeake & Ohio; C. F. Hardy, chief engineer, Appalachian Coals, Inc.; A. A. Raymond, superintendent of fuel and locomotive performance, New York Central; and R. A. Sherman, supervisor of the Fuels Division, Battelle Memorial Institute. This constructive meeting was presided over for the Fuels Division by J. E. Tobey, managing director, Coal Bureau, Upper Monongahela Valley Association, and for the Railroad Division by Lawford H. Fry, director of research, The Locomotive Institute, Inc.

Three Technical Sessions in One Day

Thursday, November 29, was a day which kept the members on the move in a way they will not soon forget—with three technical sessions, morning, afternoon, and evening, and a luncheon at noon. In the morning, an authoritative paper on "Railroad Motive Power Trends," by R. P. Johnson, chief engineer, Baldwin Locomotive Works, was read by Fred W. Schmidt, a member of the Baldwin engineering staff, owing to the unavoidable absence of Mr. Johnson. Exceptionally pertinent discussions of this paper were presented by C. W. Meyer, assistant to the president of the New York Central, and J. V. B. Duer, assistant to vice-president, Pennsylvania; Mr. Duer's paper being presented in his absence by C. K. Stein. C. E. Pond, assistant to the superintendent of motive power, Norfolk & Western, presented an inspiring talking-moving picture in technicolor, which showed the methods of servicing and performance of modern steam motive power on the Norfolk and Western. Other business at the morning session included the report of the Committee on Survey, as presented by chairman T. F. Perkinson, manager, transportation division, General Electric Company.

At the afternoon session a relatively short but thought-provoking paper, "Railroad Passenger Cars—1946 Models," was presented by A. W. Clarke, assistant general mechanical engineer, American Car and Foundry Company, followed by seven prepared discussions which effectively rounded out this important subject. Included among the discussers were D. C. Turnbull, Jr., executive assistant, Baltimore and Ohio; H. F. McCarthy, executive assistant to the president, New York, New Haven and Hartford; P. W. Kiefer, chief engineer of motive power and rolling stock, New York Central; F. L. Murphy, chief engineer, Pullman-Standard Car Manufacturing Company; K. F. Nystrom, chief mechanical officer, Chicago, Milwaukee, St. Paul and Pacific; Col. E. J. W. Ragsdale, chief engineer, railroad division, The Edward G. Budd Manufacturing Company; and J. C. Travilla, chief mechanical engineer, General Steel Castings Corporation. A paper, "Tests of Oil-Film Journal Bearings for Railroad Cars," by S. J. Needs, Kingsbury Machine Works, Inc., was also presented by title at the afternoon session.

In the evening the Railroad Division held a joint session with the Applied Mechanics Division and listened to a paper, "Crank-Pin Design for Locomotives," by O. J. Horger, chief engineer, railroad division, Timken Roller Bearing Company, and W. I. Cantley, recently retired mechanical engineer, A.A.R., mechanical division. A second paper, "Design and Application of Rail Transportation Gearing," by D. R. Meier and J. C. Rhoads, General Electric Company, was also presented. This meeting drew an attendance of less than 100, owing to the highly technical character of the papers, but presented information having a vital bearing on the satisfactory performance of steam, Diesel, and electric locomotives.

Railroad Division Members Honored

At the luncheon between the morning and

afternoon sessions on November 29, six members of the Railroad Division were honored by being advanced from the grade of "member" to "fellow."

This luncheon, with some six hundred in attendance, was presided over by E. D. Campbell, vice-president, American Car and Foundry Company, and among the guests was Alex D. Bailey, retiring president of the Society, who presented the certificates for distinctive railway-engineering achievement to the following men: K. F. Nystrom, C. T. Ripley, chief engineer, Technical Board, Wrought Steel Wheel Industry; C. E. Brinley, chairman of the board, Baldwin Locomotive Works; W. C. Dickerman, chairman of the board, American Locomotive Company; J. B. Ennis, senior vice-president, American Locomotive Company; and P. W. Kiefer, chief engineer of motive power and rolling stock, New York Central System.

Certificate of Award

At the close of the afternoon session on November 29, Chairman W. M. Sheehan was presented with a certificate as retiring chairman of the division, and a resolution was adopted calling attention to the effective work done by Mr. Sheehan for the Society over a period of years, and recommending him for nomination as one of the new directors at large for the Society.

New Officers Installed

The gavel was turned over to the new chairman of the division, K. F. Nystrom, who complimented the division on effective work during 1945 and appealed for continued support in the ambitious program planned for 1946. Including new officers installed, the Executive Committee of the Railroad Division now comprises: Chairman, K. F. Nystrom, chief mechanical officer, Chicago, Milwaukee, St. Paul and Pacific; W. C. Sanders, general manager, railway divison, Timken Roller Bearing Company; P. W. Kiefer, chief engineer of motive power and rolling stock, New York Central System; B. S. Cain, assistant engineer, locomotive division, General Electric Company; J. M. Nicholson, mechanical assistant to vice-president, Atchison, Topeka and Santa Fe; secretary, E. L. Woodward, Western mechanical editor, *Railway Age*.

General Committee

Three new members were elected for five-year terms to the General Committee, which now consists of the following: Chairman, K. F. Nystrom; A. A. Raymond, superintendent fuel and locomotive performance, New York Central; J. E. Davenport, vice-president, American Locomotive Company; H. H. Urbach, mechanical assistant to vice-president, Chicago, Burlington and Quincy; K. A. Browne, research consultant, Chesapeake and Ohio; C. M. Darden, superintendent of machinery, Nashville, Chattanooga and St. Louis; E. D. Campbell, vice-president, American Car and Foundry Company; E. R. Battley, chief of motive power and car equipment, Canadian National; E. S. Pearce, president, Railway Service and Supply Corporation; W. H. Baselt, mechanical assistant to vice-president, American Steel Foundries; E. P. Gangewere, superintendent of motive power, Reading Company; C. E. Pond, assistant to superintendent of motive power, Norfolk and Western; C. H. Beck, general sales manager, Westinghouse Air Brake Company; W. I. Cantley, recently retired mechanical engineer, A.A.R., mechanical division; F. P. Huston, development engineer, International Nickel Company; and R. P. Johnson, chief engineer, Baldwin Locomotive Works.—E. L. Woodward.

Refrigerating Engineers Elect Officers

At the 41st annual convention of the American Society of Refrigerating Engineers, which was held at the Pennsylvania Hotel on December 10, 11, and 12, 1945, Charles S. Leopold, consulting engineer, Philadelphia, Pa., was elected president for 1946.

Roland H. Money, The Reynolds Metals Co., Louisville, Ky., and Clifford F. Holske, Vilter Manufacturing Co., New York, N. Y., were elected vice-presidents. Professor Burgess H. Jennings, Northwestern Technological Institute, Evanston, Ill., will serve as treasurer during the coming year.

The following directors were also elected: John G. Bergdoll, York Corporation, York, Pa.; H. C. Diehl, The Refrigeration Research Foundation, Berkeley, Calif.; Dr. Richard C. Jordan, University of Minnesota, Minneapolis, Minn.; Dr. Mary E. Pennington, consulting engineer, New York, N. Y.; Arthur B. Schellenberg, formerly president of Alco Valve Company, St. Louis, Mo.; E. K. Strahan, Sr., E. K. Strahan, Inc., New Orleans, La.; and William S. Woodside, United Cork Companies, Baltimore, Md.

F. H. Lane Elected Chairman of Washington Award Commission

F. H. Lane, member A.S.M.E., manager of the engineering division of the Public Utility Engineering and Service Corporation, Chicago, Ill., has been elected chairman of the Washington Award Commission.

The Washington Award was founded in 1916 by John W. Alvord "in recognition of devoted, unselfish, and pre-eminent service in promoting the happiness, comfort, and well-being of humanity" and was named after the first president of the United States as a reminder of his engineering attainments.

The Award is administered by the Western Society of Engineers on recommendation of a commission representing the American Society of Civil Engineers, the American Society of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Western Society of Engineers.

John R. Michel and H. S. Philbrick represent the A.S.M.E. on the Washington Award Commission.

The first Award was made in 1919 to Herbert Hoover. In 1945 the Award was made to Arthur H. Compton.

Arthur E. Raymond Elected President I.A.S.

Arthur E. Raymond, of Santa Monica, Calif., vice-president, engineering, Douglas Aircraft Company, has been elected president of the Institute of Aeronautical Sciences, it has been announced. He succeeds Charles H. Colvin of New York, N. Y.

Cleveland Plans Engineering Center

Plans for a one and a half million dollar headquarters building or engineering center to house local engineering societies of Cleveland and Northern Ohio and to provide facilities for centering local engineering activities in one building for purposes of convenience and greater service to the community, has been proposed by the Cleveland Technical Societies Council.

The proposed building is a two-story structure containing auditoriums, meeting rooms, dining and recreation rooms, necessary for a well-integrated engineering center. Architecturally the building will be designed to reflect the "solemn dignity and serious foresight of Cleveland's engineering, technical, and scientific professions."

Cleveland engineers are confident that the funds for the building can be financed through the donations and free-will offerings of philanthropic individuals, firms, and companies interested in the advancement of engineering programs.

A. L. Ahlf Awarded Alfred Noble Prize

The Alfred Noble Prize has been awarded to A. L. Ahlf, junior member, A.S.C.E., Denver, Colo., for his paper, "Design Constants for Beams With Nonsymmetrical Straight Haunches," as announced by the American Society of Civil Engineers.

The prize consists of a certificate of award and a sum of $350. Mr. Ahlf accepted the award during the meeting of the A.S.C.E. in New York, N. Y., Jan. 16, 1946.

Index to 1945 Volume of Mechanical Engineering

As Section 2 of the January, 1946, issue of the Transactions of the A.S.M.E., separate indexes to the Transactions and to Mechanical Engineering for 1945 were mailed to A.S.M.E. members receiving the Transactions of the Society.

An additional copy of the index to Mechanical Engineering may be secured from A.S.M.E. Headquarters, 29 West 39th Street, New York 18, N. Y., by sending ten cents for handling charges.

Actions of A.S.M.E. Executive Committee

At a Meeting Held at Headquarters, Dec. 20, 1945

A MEETING of the Executive Committee of the Council of The American Society of Mechanical Engineers was held at Society Headquarters on December 20, 1945. There were present: D. Robert Yarnall, chairman, D. S. Ellis, R. F. Gagg, J. N. Landis, A. R. Stevenson, Jr.; W. H. Sawyer (Finance), J. A. Goff (Professional Divisions), A. R. Mumford (Sections); K. W. Jappe, treasurer, C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary.

Meetings and Program

Upon joint recommendation of the Committees on Meetings and Program and Sections, it was decided to approve holding the 1946 Spring Meeting in Chattanooga, Tenn., April 1–3, and the 1946 Fall Meeting in Boston, Mass., September 30–Oct. 2.

Professional Divisions

It was also decided to approve the following Professional Divisions Meetings in 1946: Applied Mechanics, Buffalo, N. Y., June 21–22; Textile, Greenville, S. C., date to be announced; Oil and Gas Power, Milwaukee, Wis., June 12–15; Joint Conference A.I.M.E. Coal and A.S.M.E. Fuels Divisions, Philadelphia, Pa., Oct. 24–26; Aviation, Berkeley, Calif., June 3–5; Petroleum Committee, Process Industries Division, Tulsa or Oklahoma City, Okla., September, 1946.

Research

Upon recommendation of the Research Committee, approval was voted of the extension to April 1, 1946, of the contract between the U. S. Army Ordnance Department and the Society for the research program on Finishing and Machining of H. E. Steel Shells.

Standardization

Upon recommendation of the Standardization Committee, approval was voted of the adoption as a standard of the Society and for transmission to the American Standards Association for approval as an American Standard, the proposed American Standard for Life Tests of Single-Point Tools Made of Materials Other Than Sintered Carbides.

Development Fund

It was noted with satisfaction that contributions to the Development Fund as of December, 20, 1945, amounted to $104,779.

International Book Fund

In connection with the appeal being made by the Committee on International Relations for contributions of technical books and magazines and donations in money with which "to restock war-devastated libraries, to modernize those that by the hostilities have been shut off from the outside world, and to advance technical progress in countries where it hitherto has not been developed," it was voted (1) to approve the activities of the Committee on International Relations whereby contributions of technical books and magazines would be solicited, and (2) to approve the establishment of an International Book Fund for donations in money for the purchase of technical literature.

Atomic Power

In connection with the authorization given by the Council at its meeting Nov. 25–26, 1945, for the appointment of a committee to develop and report to the Executive Committee on a program of Society activity on the application of new developments in nuclear physics, it was decided to appoint Alex D. Bailey, George B. Pegram, and Brig. Gen. W. I. Westervelt a committee of three to suggest a program of Society activity in connection with the engineering application of atomic power.

Certificates of Award

Upon recommendations of the respective Committees, it was decided to approve Certificates of Award for Carl L. Bausch, retiring chairman of the Board of Honors and Awards; George L. Sullivan, retiring chairman of the Committee on Relations With Colleges; F. G. Switzer, retiring chairman of the Committee on Meetings and Program; Charles E. Gorton, retiring member of the Boiler Code Committee; M. D. Stone, retiring chairman of the Executive Committee of the Metals Engineering Division.

E.I.C. Participation in Semi-Annual Meeting

An invitation was extended to the Engineering Institute of Canada to participate in the Semi-Annual Meeting of the Society to be held in Detroit in June, 1946, by attendance and by the presentation of selected papers as agreed upon by the Committee on Meetings and Program.

Institution of Engineers of India

It was noted with approval that on the occasion of the Silver Jubilee Session of the Institution of Engineers of India held in Calcutta, India, Dec. 27 to 31, 1945, the Society extended greetings to the Institution and commendation on the "spirit of public service that unites the engineers of India for the benefit of her people."

Death of Charles A. Baker

The death on December 7, 1945, of Charles A. Baker who, as a member of the firm of Parker and Aaron, had been the Society's counsel as well as counsel for the U.E.T. and the other Founder Societies for many years, was noted with regret, and an expression of sympathy was sent to the family of Mr. Baker.

International Screw Thread Standards

On invitation of W. L. Batt, American chairman of the Combined Production and Resources Board, President Yarnall attended a meeting on November 28, 1945, of individuals interested in new standards on screw threads agreed upon by Great Britain, Canada, and the United States. It was felt desirable to establish a steering committee to support the adoption of these standards by American industry and the Executive Committee of the Council voted to support the adoption of the new standards on screw threads and to authorize the President to appoint the necessary representation.

George Westinghouse Centennial

As 1946 is the year of the centennial of the birth of George Westinghouse, it was voted to convene a special meeting of the Society on February 26, in New York, at which recognition will be given to the achievements of "George Westinghouse, the Man," this celebration to be under the general guidance of a committee to be headed by Dexter S. Kimball.

American Arbitration Association

Approval was voted of participation in the twentieth anniversary of the founding of the American Arbitration Association, representation to be provided by the Management Division.

I.E.S. Lighting Handbook

THE Illuminating Engineering Society has announced that Robert W. McKinley, electrical engineer, has been engaged as editor of the forthcoming I.E.S. Lighting Handbook scheduled for issuance in October, 1946.

The I.E.S. Lighting Handbook will contain 500 pages of text prepared by authorities in their respective fields. It will cover every phase of lighting from the pure physics of light to specific recommendations for stores, offices, homes, and factories. There will be 16 sections, including the latest information on light source and the measurement and control of light.

A.S.M.E. Calendar

of Coming Meetings

April 1–3, 1946
A.S.M.E. Spring Meeting
Chattanooga, Tenn.

June 3–6, 1946
A.S.M.E. Aviation
Division Meeting
Los Angeles, Calif.

June 12–15, 1946
A.S.M.E. Oil and Gas Power
Division Meeting
Milwaukee, Wis.

June 17–20, 1946
A.S.M.E. Semi-Annual Meeting
Detroit, Mich.

June 21–22, 1946
A.S.M.E. Applied Mechanics
Division Meeting
Buffalo, N. Y.

September 30–Oct. 2, 1946
A.S.M.E. Fall Meeting
Boston, Mass.

December 2–6, 1946
A.S.M.E. Annual Meeting
New York, N. Y.

Among the Sections

MEETING OF BRIDGEPORT SECTION AT STRATFIELD HOTEL, BRIDGEPORT, CONN.

"Powder Metallurgy" Talk at Bridgeport Section

Malcolm F. Judkins, member A.S.M.E., chief engineer, Firth-Sterling Steel Company, was the speaker at the Dec. 13 meeting at the Stratfield Hotel, Bridgeport, Conn. He proved to be an authority on his subject, "Powder Metallurgy," and an audience composed of engineers conversant with and anxious to acquire knowledge on the subject, were enthusiastic over Mr. Judkins' presentation. The speaker is recommended to all sections.

Beginning January 4, and on Jan. 11, 18, 25, and Feb. 1, the Section sponsored a course in Electronics at the Central High School, Bridgeport, Conn. Five lectures were delivered by Prof. Herbert L. Krauss of the electrical-engineering division, Yale University. The course covered the fundamentals of the subject and illustrated various applications in radio, radar, television, and in particular the applications to industrial controls.

Atlanta Section Meets With Georgia Tech Branch

A joint meeting with student members at Georgia Tech was held on December 8 at Brittain Hall, Atlanta, Ga., when the speaker was Earle Mauldin, member A.S.M.E., southern editor, McGraw-Hill Publishing Company, Inc., Atlanta, Ga. His subject was "Graduate Engineering Activities on Entering the Profession." Five other speakers outlined matters of interest to graduate engineers; these were: R. M. Benjamin, Bob Griffith, O. O. Rae, R. S. Lynch, and E. J. Stern.

"Pan American Highway" Talk at Baltimore Section

On Nov. 15 at the Engineers' Club of Baltimore, Md., Senor Don Eugenio de Anzorena, second secretary in the Mexican Embassy, Washington, D. C., discussed the cultural and economic ties afforded by the Pan American Highway. Julian L. Schley, former governor of the Panama Canal, and now executive director of the Baltimore Aviation Commission, spoke briefly. Two hundred members and guests were present.

The Baltimore Section in joint meeting with the Maryland Section of the A.S.C.E. drafted and approved for transmittal to Washington a resolution in support of Senator Warren G. Magnuson's bill to create a national research foundation headed by a board of nongovernmental experts, and in opposition to the Kilgore bill proposing that the body be headed by an administrator appointed by the President.

Boston Section Hears Dr. Den Hartog

On Dec. 13 at Northeastern University Dr. J. P. Den Hartog, member A.S.M.E., spoke on "Experiences in Europe." The talk, illustrated with 100 slides, told of his experiences during a period of technical survey for the Armed Forces. Dr. Den Hartog described conditions as he found them in Germany, France, Holland, and Belgium. He also discussed the use made by the Germans of hydrogen peroxide as a propulsion agent and as a substitute for oxygen in submarine warfare. One hundred and twenty five were in attendance.

Columbus Section Hears Discussion on German Technology

A round-table discussion was held at Battelle Memorial Institute, Columbus, Ohio, Dec. 13, when Dr. S. L. Hoyt, Prof. Alfred Lande, and Walter Robinson, member A.S.M.E., led by Dean Charles E. MacQuigg, discussed the subject "What Can We Learn From German Technology?" These speakers have visited German plants and research laboratories and interviewed German scientific workers, and the discussion centered around the organization, manpower, materials, and techniques which were used in Germany to prosecute the war. It was the opinion of the discussers that German technology was organized and coordinated at a rather late date, and was therefore not as effective as it might have been. The discussion also covered the control of German technology to prevent its concentration for military purposes.

Collective Bargaining Discussed at Detroit Section

On Dec. 4 a meeting was held in the Rackham Building, Detroit, Mich., when Prof. Leo Wolman, National Bureau of Economic Research, New York, N. Y., spoke on "Industry-Wide Collective Bargaining." Professor Wolman defined collective bargaining and explained how it functioned. He pointed out its defects, as applied on an industry-wide basis. In the discussion that followed his talk many points of interest were brought out. Five hundred members and guests were present.

Central Illinois Section Hears Talk on Magnesium

At the meeting on Dec. 13 in the Caterpillar Theater, Peoria, Ill., D. W. Moll, Hills-McCanna, Chicago, Ill., spoke on "Magnesium." He said that the future of magnesium was considered bright, as it can be used wherever a light metal is desirable. He stressed its easy machinability and light weight. A total of 60 members and visitors were present.

Ithaca Section Hears F. T. Lyons

"Precision Measurement Clinic" was the subject chosen by F. T. Lyons of DoAll-Hudson Company, Syracuse, N. Y., at the meeting on Dec. 5, at the Arlington Hotel, Binghamton, N. Y. Mr. Lyons explained the use and care of gage blocks, optical flats, comparators, and other inspection equipment and illustrated his talk with the aid of a phonograph projector. A comprehensive display of equipment was on exhibit.

Colonel J. F. Brown Heard at Kansas City Section

An interesting meeting was held at the University Club, Kansas City, Mo. on Nov. 12, when the speaker was Colonel J. F. Brown, Corps of Engineers, U. S. Army. Colonel Brown has been commanding officer of the 110th Engineers in Kansas City for some time, and recently activated an engineers' port construction and repair group in the South Pacific. His experiences during this tour of duty were extremely interesting and very well told. Over 40 members attended and enjoyed the meeting.

At the Dec. 2 meeting held in the University Club, Kansas City, Mo., the guest speakers were Messrs. Place and Van Brunt of the Combustion Engineering Company. Their subject, "Boiler Carry-Over and Boiler Design," was heard by an audience of 57. They explained that boiler carry-over is the water and dirt entrained in the steam. They said that the first step was water separation, removing 95 per cent of the water; the second step, steam washing which removes the dirt from the remainder; and the third step, purification, which removes all but one part in one million of the remaining water. Slides were shown of various boilers with their design curves and other data.

J. D. Duncan, Speaker at Ontario Section

On Dec. 13 at Hart House, University of Toronto, Toronto, Ont., Can., J. D. Duncan of the Canadian General Electric Company, spoke on "Motor Selection." He discussed the factors to be considered before ordering motors and outlined particulars which should be supplied to motor manufacturers. Mr. Duncan used slides to illustrate applications of motors in various industries. Forty were present.

Inspection Trip Made by Cleveland Section

The Dec. 13 meeting was an inspection trip through the Engine Research Laboratory of the National Advisory Committee for Aeronautics, which is located at the Cleveland, Ohio, airport. Sixty members and guests enjoyed this instructive trip.

Advantages of "Meehanite" Explained at Colorado Section

"Meehanite in Industry" was the subject discussed by R. W. Akerlow at the Dec. 14 meeting at the Oxford Hotel, Denver, Colo. Mr. Akerlow explained the advantages of various types of Meehanite over ordinary cast iron, such as increased tensile strength, elasticity, and machinability. A sound movie emphasizing the value of this product as an engineering material was shown.

J. S. Perkins Speaker at Chicago Section

On Dec. 18 in the Civic Opera Building's Little Theater, Chicago, Ill., J. S. Perkins, chief of personnel and results, Western Electric Corporation, gave a talk on "Time and Motion Study as a Means of Increasing Productivity." Mr. Perkins said that today's increasing labor demands means that management must do a better job in labor utilization. He explained that time study is a management tool, while motion study is a method of changing work methods. Both increase production 30 to 60 per cent. The third factor to be considered in such a program, he added, is the industrial-relations aspect which has to be properly handled in each individual case in order to have a smooth program.

Cincinnati Section Hears Dr. Lillian M. Gilbreth

On Nov. 6 at the Schneider Memorial, Cincinnati, Ohio, a joint meeting was held with the A.S.C.E. and Engineering Society of Cincinnati, featuring Dr. Lillian M. Gilbreth, member A.S.M.E., president, Gilbreth, Inc., Montclair, N. J., who spoke on "The Engineers' Place in Industrial Personnel and Operation."

In her talk Dr. Gilbreth mentioned important transitions from war production where quantity and speed were the main considerations, to peace when no longer all money, all workers, and all possible outside help were available. She asked for a fair evaluation of women's accomplishments in war work and spoke of the great importance of industrial medicine and corrective exercises at work, physical and physiological tests, as well as aptitude testing suggested for selection of workers. Two hundred members and guests were present.

The annual bowling party and get-together was held at the Maketewah Country Club, Cincinnati, Ohio, on Dec. 7. The affair, arranged by Ed. Sauerbrunn, proved most enjoyable and was well attended.

The Dec. 19 meeting at the Engineering Society Headquarters Building, Cincinnati, Ohio, featured E. J. H. Bussard, supervisor of the Engineering Development Laboratory of the Crosley Corporation. Mr. Bussard discussed the V.T. (Radio Operated) "Proximity Fuse" one of the closely guarded secrets of the war, ranking with radar and the atomic bomb. The talk was illustrated with official Office of Scientific Development and Research movies, showing the manufacture and testing of these shells against radio-controlled targets. Dr. Allen Hynek, of Johns Hopkins Foundation told in narrative form his part in the field-testing of the fuses.

MILWAUKEE SECTION PLANT A.S.M.E. PROMOTERS

(The Milwaukee Section held a meeting for the plant A.S.M.E. promoters on Nov. 5, 1945, in the Poinsettia Room of the Medford Hotel, Milwaukee, Wis. This group of the Milwaukee Section A.S.M.E. representatives is responsible for the ticket sales and bulletin-board advertising necessary in the plants for successful dinner meetings and in general promotes attendance and morale for the Section activities. Don Maulin as chairman of the Meetings Committee is in charge of the activities of the plant promoters. *Seated, left to right;* V. E. Johnson, Carl Stessl, Geo. Minniberger, Theodore Wetzel, Harold Heywood, Russel Smith, Robert Fobian. *Standing, left to right;* H. B. Reiber, Jas. F. Roberts, Richard Meiners, Emil Neubauer, Don Maulin, Warren Weithofer, J. Verne Resek, Joe Drinka.)

Philadelphia Section Hears Talk on Design Features of Southwark Station

On Dec. 11 a dinner meeting was held at the Engineers' Club, followed by a joint meeting with the A.S.C.E. at the Edison Building, Philadelphia, Pa. The speaker was James H. Harlow, member A.S.M.E., assistant mechanical engineer, Philadelphia Electric Company, Philadelphia, Pa., whose subject was "Design Features of Southwark Station." Mr. Harlow outlined the complete project from initial test borings and pile tests at the site, through boiler room and turbine room to the switch house. Of particular interest was the use of working-scale models to check circulating-water discharge, flame travel, and flue-gas discharge from the stacks. Mr. Harlow led a group of his associates, each responsible for a particular portion of the design, in a panel discussion, and questions from the audience were encouraged. The complete presentation conveyed the impression of an engineering project that is being carried through with particular thoroughness. Welcome visitors at the meeting included Colonel C. E. Davies, secretary, A.S.M.E., who spoke briefly on the possible benefits of joint activities undertaken by groups belonging to different engineering societies; delegations from Reading, Pa., headed by E. M. Gilbert; from Baltimore, Md., headed by A. L. Penniman, and J. H. Potter, chairman, Baltimore Section; and from the Public Service Electric and Gas Company of New Jersey, headed by Herman Weisberg. The audience totaled over 400.

EXECUTIVE COMMITTEE OF THE PHILADELPHIA SECTION

(*Front row, left to right:* M. C. Randall, Justin J. McCarthy, S. T. MacKenzie; *Second row, left to right:* J. P. Clark, F. W. Miller, A. W. Thorson, B. F. Keene; *third row, left to right:* H. Schock, Jr., G. B. Thom, C. B. Campbell, W. J. Kinderman.)

"Jet Propulsion" Subject at Providence Section

Charles L. Ray, chief, flight research, Bell Aircraft Corporation, Buffalo, N. Y., was the speaker at the Dec. 4 meeting held in the Providence Engineering Building, Providence, R. I. With his talk, entitled "Report on Jet Propulsion," Mr. Ray used a colored sound film with the same title, and also a film on the Bell helicopter, these films illustrating the extremes of aircraft propulsion. A question period followed, and the audience of 162 praised the excellence of the presentation.

Rochester Section Has Two Meetings in December

A joint meeting with the A.I.E.E. was held on Dec. 6 when an inspection trip was made through Station 3, Rochester power plant, the first permitted since the war ended. The trip was made under the direction of Ralph H. McCumber, superintendent electric and steam generation, and Arthur C. Rissberger, assistant personnel director.

On Dec. 13 at the Hotel Sheraton, Rochester, N. Y., a joint dinner meeting was held with the Rochester Engineering Society, when the speaker was Everett S. Lee, member A.S.M.E., engineer, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y. Mr. Lee spoke on "What Is New in Science and Engineering" and the audience found his address exceedingly worth while.

Modern Tool Steels—Talk at East Tennessee Section

On Jan. 8 a joint meeting was held with the A.S.C.E. and A.I.E.E. in the Chattanooga Power Board Auditorium, Chattanooga, Tenn., when G. E. Brumbach, metallurgical engineer, Carpenter Steel Company, Reading, Pa., discussed the manufacture and uses of modern tool steels which will make possible the tremendous production of airplanes, automobiles, radios, washing machines, and the myriad other things which the public now wants and expects industry to supply. Mr. Brumbach said that "tooling up," a phrase formerly used only by mechanical engineers and industrialists, is now in the vocabulary of all engineers because of the publicity given to the vitally important machine-tool industry during the recent war. His talk was illustrated with slides and blackboard diagrams.

"Collective Bargaining" Discussed at Mid-Continent Section

Stan Learned, chairman of operating committee for the Phillips Petroleum Company, was the speaker at the Dec. 4 meeting at Bartlesville, Okla. Mr. Learned presented a paper entitled "Collective Bargaining for Engineers." He discussed the pros and cons on joining established unions; organizing separate bargaining agencies, and taking a definite stand against collective bargaining in any form. An excellent, impartial analysis of the problems was presented, together with a report of activities throughout the nation toward organizing engineers. Mr. Learned did not give his personal views but gave quotations from various sources. The talk was followed by a lively discussion. The attendance was 104.

The regular monthly meeting was held on Dec. 13 at the University of Tulsa, Okla. W. H. Steinkamp, Brown Instrument Company, Philadelphia, Pa., was the speaker. He illustrated his talk, entitled "Some Practical Aspects of Automatic Control," with slides showing the various types of instruments and their installation.

St. Joseph Valley Section Makes Plant Inspection

On Dec. 13 a meeting was held at the Mishawaka Hotel, Mishawaka, Ind., when Mr. Carver, vice-president, Dodge Manufacturing Corporation, spoke on "History of the Dodge Manufacturing Corporation." The members were guests of the Dodge Corporation for dinner, and following the talk, made an inspection trip through the corporation's plant.

"Silicones"—Subject at San Francisco Section

On Nov. 29 a dinner meeting was held at the Engineers' Club, San Francisco, Calif. The speaker was W. L. Nelson, Dow Chemical Company, who spoke on "Silicones." Mr. Nelson had just returned from the East, where he obtained much late information on the manufacture and use of silicone compounds; he had numerous samples which he passed on to the audience to inspect. He described the advantages of silicone compounds for waterproof coatings, high-temperature lubricants, heat-transfer liquids, vibration-damping media, high-temperature insulation, and other applications. A lively discussion followed his talk.

Western Washington Section Hears Talk on Gears

On Oct. 3 S. L. Crawshaw, member A.S.M.E., Western Gear Works, Seattle, Wash., was the speaker at a dinner meeting held at the Engineers' Club, Seattle, Wash. Mr. Crawshaw spoke on the subject of "Gears and Their Place in Modern Industry." A very interesting evening was enjoyed by the audience of 120.

Dr. R. Jenkins, junior member A.S.M.E., Pacific Coast steam engineer, Westinghouse Electric Corporation, spoke on "The S-2 Geared-Steam-Turbine Locomotive" at the meeting of Nov. 29 at the Engineers' Club, Seattle, Wash. He ably discussed the salient features of turbine-geared driving and illustrated with slides. He stated that there must be advances in rail transportation to compete with new air-line transport services. Seventy-four members and guests were present.

I. M. White, C.E., Speaks at Southern California Section

I. M. White, civil engineer with the Pelton Water Wheel Company, San Francisco, Calif., was the speaker at the Nov. 29 meeting in the Clark Hotel, Los Angeles, Calif. In his talk entitled "From Raindrops to Kilowatts," Mr. White presented an excellent verbal picture of hydroelectric power-plant design problems, with particular emphasis on the Pit No. 5 development of the Pacific Gas and Electric Company. Colored slides were used to illustrate actual installations and factory views showing construction details of water-wheel turbines. An audience of 90 enjoyed the lecture.

"Combustion Problems" Subject at Virginia Section

A meeting was held in Ewart's Cafeteria, Richmond, Va., on Dec. 14 when Dr. F. G. Baender, member A.S.M.E., associate professor mechanical engineering, University of Missouri, Columbia, Mo., spoke on "Combustion Problems." He discussed the practical aspects of combustion problems as applied to household furnaces. He emphasized the importance of draft regulations for coal and oil burners and said that excess air and unburned fuel constitute the cause of low efficiency in this type of furnace. Seventy-five members and guests were present.

Washington, D. C., Section Holds Two Important Meetings

On Dec. 7, 1945, a meeting was held in the P.E.P. Company Auditorium, Washington, D. C., when Dr. Curt Keller, director of research of the Escher-Wyss Company, Zurich, Switzerland, spoke on "The Escher-Wyss AK Closed Cycle Air Turbine for Marine and Stationary Power Plants." Dr. Keller, known mainly for his research in turbine machinery, is the co-inventor of the Akaeret-Keller Closed Cycle Gas Turbine. A dinner at the Harrington Hotel preceded the lecture.

S. L. CRAWSHAW ADDRESSING WESTERN WASHINGTON SECTION. FAIRMAN B. LEE, CHAIRMAN, AT RIGHT

On February 14 in the P.E.P. Company Auditorium, Washington, D. C., four speakers gave talks on the subject of locomotives. They were: Dr. J. T. Rettaliata, junior member A.S.M.E., director of the mechanical-engineering department, Illinois Institute of Technology, Chicago, Ill., and consulting engineer on gas-turbine development for Allis-Chalmers Manufacturing Company, Milwaukee, Wis., who spoke on the gas-turbine locomotive; R. Tom Sawyer, member A.S.M.E., engineer, Diesel equipment, American Locomotive Company, New York, N. Y., who spoke on the Diesel engine; Charles E. Heilig, preliminary engineering department, Baldwin Locomotive Works, Philadelphia, Pa., who spoke on steam locomotives; and W. A. Brecht, manager, transportation engineering, Westinghouse Electric Corporation, East Pittsburgh, Pa., who spoke on the electric locomotive.

"Physical Aspects of Railway Development" Subject at Waterbury Section

An informal dinner meeting was held at the Hotel Elton, Waterbury, Conn., on Dec. 5, followed by a talk by Clair B. Peck, managing editor of the "Railway Mechanical Engineer." Mr. Peck discussed the wonderful job that was done by the American railroads in the war and gave comparative statistics with the first world war. He explained just what developments had taken place between the two wars to make this record performance possible. A question period followed in which Mr. Peck answered many varied and interesting questions concerning railroads and equipment. It was a very interesting evening and Mr. Peck is recommended as a speaker for other sections.

Col. W. B. Tuttle Honored by South Texas Section

A dinner meeting honoring Col. W. B. Tuttle was held on Dec. 11 in the Cascade Room, St. Anthony Hotel, San Antonio, Texas. Colonel Tuttle became a member of the A.S.M.E. in 1905, and throughout all the years of his membership his interest in the Society has been sustained. Upon recommendation of the South Texas Section, he has now been promoted from the status of member to the rank of Fellow, an honor which he richly deserves, and one which has been accorded to Texans upon very rare occasions. A certificate was presented to Colonel Tuttle, making him a Fellow of the Society.

Study of Stoker Fuel Beds at Worcester Section

At the meeting on Dec. 5 held at the Worcester Polytechnic Institute, Worcester, Mass., Otto de Lorenzi, member A.S.M.E., of the Combustion Engineering Company, New York N. Y., spoke on "Study of Stoker Fuel Beds and the Effect of Overfire Air." Mr. de Lorenzi discussed the use of photography in the study of fuel beds and illustrated his talk with pictures in color which were taken every 10 sec and shown at 16 per sec. Others were taken at 4000 per sec and shown at 16 per sec. Four slides illustrated the different types of stokers, and then followed reels of color-movies taken inside the furnaces. These latter showed the effect of overfire air and also steam jets. Seventy-five members and guests heard this interesting talk and were enthusiastic over the remarkable photography.

S.A.E. Elects Officers

THE Society of Automotive Engineers elected L. Ray Buckendale, Timken-Detroit Axle Company, president for 1946 at the annual meeting held in the Book-Cadillac Hotel Jan. 7 to 11, 1946.

Eleven new vice-presidents were also elected. They are: George A. Page, Curtiss-Wright Corporation, Buffalo, N. Y.; Earle A. Ryder, Pratt & Whitney Aircraft, East Hartford, Conn.; Charles Froesch, Eastern Air Lines, New York, N. Y.; H. S. Manwaring, International Harvester Co., Chicago, Ill.; J. C. Geniesse, The Atlantic Refining Co., Philadelphia, Pa.; J. E. Hale, The Firestone Tire and Rubber Co., Akron, Ohio; Thomas L. Hibbard, Ford Motor Co., Detroit, Mich.; E. A. Petersen, Massey-Harris Co., Racine, Wis.; Ervin N. Hatch, New York City Transit System, New York, N. Y.; Beverly W. Keese, Timken-Detroit Axle Co., Oshkosh, Wis.; and Niel A. Moore, Sealed Power Corporation, Muskegon, Mich.

Student Branches

University of California Branch

On Nov. 30 a meeting was held in 104 Engineering Building. Al Strong, chairman, called the meeting to order and introduced the guest speaker, Carl Vogt, who was a commander in the Navy and did research work in Europe durin the war. His talk was extremely interesting, and an informal discussion followed.

College of the City of New York Branch

On Oct. 11 Andrew J. Goss, chief engineer of De Mornay Budd, Inc., New York, N. Y., spoke to the members on "Production Methods in Engineering." Among the points made by Mr. Goss was the fact that engineering design is completely dependent upon production methods. Thus, he said, better engineering design in all branches will be obtained if the designing engineer has a better comprehension and knowledge of production methods.

The meeting on Oct. 18 presented Prof. Stephen J. Tracy, faculty adviser, who spoke on "Aims of the A.S.M.E." Drawing from his long experience with the Society, both as student member and member of the A.S.M.E., as well as his position as faculty adviser in the University of Pittsburgh, and at the City College of New York, Professor Tracy listed the advantages of being a member of the A.S.M.E. His talk also emphasized the responsibilities and obligations which the engineer must assume upon his entrance into the profession.

On Nov. 1 the speaker at the meeting was Chester Hammond, assistant to the assistant-vice-president, Pan American World Airways, who gave a talk on "Postwar International Air Transportation." Mr. Hammond discussed the economic and social effects of the great increase in international air travel and illustrated his talk with a technicolor sound film "Wings to Alaska."

The meeting on Nov. 8 had as its speaker Malcolm F. Judkins, member A.S.M.E., chief engineer, Firth-Stirling Steel Company, McKeesport, Pa., whose subject was "Powder Metallurgy." Mr. Judkins said that powder metallurgy was different from ordinary metallurgy in that no melting or casting of the liquid metal is involved. Instead, the finely divided particles of the metal are pressed together under tremendous pressure and heated to two thirds of the melting point of the liquid metal. He told of the advantages of powder metallurgy and accompanied the lecture with a sound film "Firthite," which described sintered-carbide cutting tools.

University of Cincinnati Branch

The first meeting of the new school year was held on Nov. 7 in the Student Union Building. Plans were made to draw up a budget, and decision made to hold a meeting on Nov. 15, inviting all new members. At the meeting on Nov. 15, which was attended by all new and prospective members, plans for the coming year were made, and standing committees were appointed. Prof. R. L. Smith, member A.S.M.E., the new honorary chairman, spoke about the Society, explaining the background and purpose of A.S.M.E.

On Dec. 5 a meeting was held in the Student Union Building, when the budget was read and approved. The athletic chairman gave his report on intramural sports. A Christmas party was held on Dec. 21.

Clemson A.&M. College Branch

On Nov. 8 the first program meeting in more than a year was held in the Shop Building. After a short business discussion, two films of current interest were shown, "The Power Within: Story of the Internal-Combustion Engine," and "Diesel—The Modern Power."

The meeting on Nov. 26 featured a talk by Prof. F. T. Tingley of the electrical-engineering department, who spoke on "Electronics and the Mechanical Engineer." Professor Tingley also gave a demonstration of the electronic tube in use.

University of Idaho Branch

The meeting on Oct. 17 at Kirtley Laboratory was opened by D. Kamp, chairman, who introduced the speaker, Mr. Jenings of the Minneapolis - Honeywell Company. Mr. Jenings presented two films and a demonstration on the new air-conditioning development "Moduflow."

At the meeting on Oct. 30 a talk was given by Prof. H. F. Gauss, member A.S.M.E., honorary chairman, on the organization of the A.S.M.E. A motion was presented and approved that the Branch sponsor the Minneapolis-Honeywell school program, with the understanding that these meetings are to be of an extracurricula nature, and that they do not conflict with the regular meetings.

A sound film on the manufacture of carbon and graphite electrodes was the feature of the Nov. 5 meeting. Committees were appointed for the coming engineers' ball.

University of Kansas Branch

The meeting of Dec. 18 at Marvin Hall featured a lecture, "Engineers in Business," by Charles Briggs, personnel-relations manager, Marley Cooling Tower Company, Kansas City, Mo. In his talk Mr. Briggs offered several helpful hints on how to get a job and expressed his desire and belief that in the near future a universal organization for engineers would be in existence. He said that the engineering profession would and should be more efficiently organized, to be comparable with the organizations now functioning in the law and medical professions. A round-table discussion followed his interesting talk. Prof. E. S. Gray, member A.S.M.E., chairman of mechanical engineering at the University of Kansas, gave a short talk on the merits of being student members of the A.S.M.E. At the end of the meeting several new members were elected.

University of Maryland Branch

A joint meeting was held on Nov. 25 in Room E 18, with the A.S.C.E., A.I.E.E., and A.I.Ch.E. Dean S. S. Steinberg, who has recently completed a tour of the engineering schools of South and Central America, gave an interesting and entertaining talk. He compared methods of teaching and administration, use of textbooks and equipment, and arranged for exchange of professors with North American colleges. In his talk Dean Steinberg pointed out two of the major differences in the method of teaching; in Latin America faculties are all part-time, practicing engineers merely giving lectures several hours a week; and no textbooks are used and very little outside study is required. Many amusing and interesting incidents which occurred during his travels were related by Dean Steinberg.

University of Nebraska Branch

On Nov. 28 a meeting was held in 206 M.E., when Prof. N. H. Barnard, member A.S.M.E., honorary chairman, announced a tentative inspection trip for Dec. 19 as guests of the Omaha Engineers Club, Omaha, Neb. Election of officers was held, with the following result: Shigeo Nakanishi, chairman; Irvin L. Reis, vice-chairman; Irwin C. Cone, secretary; Matthew Russel, treasurer. Professor Barnard then gave a talk on "Quality Control by Statistical Methods," which was a highly interesting and informative presentation of a method of controlling the quality of manufactured products. This method is a successful wartime development, with wide possibilities for use in peacetime industries.

New York University Branch

At the first meeting of the term, on Nov. 14, at Lawrence House, Prof. D. B. Porter, member A.S.M.E., of the administrative engineering department, spoke on "Methods of Doing Work." A pioneer in the field of motion and time study, Professor Porter pointed out that the only way to raise industrial wages was to increase the productivity per man. How methods study helps in increasing productivity was well illustrated by motion pictures.

On Dec. 18 at Lawrence House, the speaker was Professor O'Connor, a member of the newly established safety-engineering department, who lectured on "Safety Devices and Safety in the Shop." During the war Professor O'Connor had supervision of all safety and hygiene at the Styrene-Butadiene plant near Pittsburgh, Pa., and in the course of his talk he pointed out that safety should be built into machinery on the drafting board, and not be improvised later in the field.

Northeastern University Branch

On Nov. 14 a meeting was held in 58 Richards Hall, with 40 members present. Elections were held, with the following result: Robert Saumsiegle, chairman; James Rawnsley, vice-chairman; Robert Wiener, secretary; George Streechon, treasurer; Felix Moscatelli, publicity; Robert Harrison, social chairman, and Frank Lambert, program. It was suggested that a dance be held jointly with the S.A.M.

Mr. Borden, of the Westinghouse air-conditioning division of Westinghouse Elec-

UNIVERSITY OF NEBRASKA BRANCH

(*Front row, left to right:* J. W. Haney, Shigeo Nakanishi, chairman; Theron J. Thaden, Prof. N. H. Barnard, honorary chairman. *Middle row, left to right:* P. K. Slaymaker, Irwin C. Cone, secretary; Harry Saunders, Tom Shiokari, Edwin J. Busch, Jr. *Back row, left to right:* J. K. Ludwickson, Irvin L. Reis, vice-chairman; Raynold J. Sedlak, Ralph Kell, and Arthur A. Hehnke.)

tric Corporation, was the speaker at the meeting on Dec. 20. In his talk, entitled "Future of Air Conditioning," Mr. Borden gave a brief history of air conditioning, outlined early developments in the field and early uses, and gave a summary of the future in home air conditioning. He said that one of the best opportunities offered the young engineer is in industrial installation design where each application is a new problem.

Northwestern University Branch

The meeting on Nov. 23 at Tech Institute was called to order by the president, William Eller, after which a short business meeting was held. The program consisted of a sound film "Bridging San Francisco Bay," and a short talk on the San Francisco Bridge by I. T. Wetzel, junior member A.S.M.E., a faculty member of the mechanical-engineering department. Mr. Wetzel was associated with the design of the bridge during the initial phase of its construction, and his talk and the ensuing question period proved instructive and interesting to the audience.

University of Puerto Rico Branch

A meeting was held on Nov. 30 in one of the college rooms, when a committee was appointed to take care of activities. The following members were appointed: Rafael Labiosa, Crispulo Pereira, Hector Brenes, Fernando Felices, and Julio Muniz.

University of Rochester Branch

A meeting was held on Nov. 27 in the Engineering Building, when final plans were made for a dance to be held in December. Plans were also made for inspection trips, and members were asked by Jack Krosse, chairman, to present suggestions as to how the branch can help to promote closer ties with the other engineering organizations on the campus. Professor Leet of the engineering staff gave a talk on the developments to be expected in the future, with emphasis on science and education. He maintained that we should have no fear for the future, despite the fact that atomic energy is capable of vast destruction. Instead, he urged that we be optimistic, for he envisioned an age of scientific and industrial advancement in which man will reap many rewards for his efforts.

University of Southern California Branch

The first meeting of the winter term was held on Nov. 8 in the Engineering Building. J. Calachis, the new chairman, opened the meeting. New business was discussed, and a tentative program presented. Applications were distributed to new members.

The next meeting was held on Nov. 15 in 104 Engineering Building, when a technicolor film was shown entitled "Frequency Modulation." Old and new members were welcomed by the honorary chairman, H. A. Johnson, junior member A.S.M.E. The new officers were introduced by Albert Strong, chairman. These are: Bob Hirsch, vice-chairman; Barbara Quimby, secretary; and Bill Gray, treasurer. Committees were appointed for Programs and Papers, Membership, Publicity, Inspection Trips, Social, and Placement. Two representatives were elected to the Engineers' Council.

On Nov. 15 the program consisted of a technicolor film entitled "The Los Angeles Aqueduct."

University of Tennessee Branch

At the first regular meeting on Oct. 17 Professor Morton gave an illustrated talk on "Recent Advances in Motive Power." Officers elected at the organizational meeting on Oct. 3 were: George Rogers, president; Robert Nelson, vice-president; Mary Porter Fain, secretary-treasurer, and Bill Arnold, ACE board representative.

Tufts College Branch

On Nov. 20 a lecture on "Atomic Power Engineering" was heard by 28 members who journeyed to Harvard University to hear A. C. Klein and R. R. Wisner of the Stone and Webster Engineering Corporation, Boston, Mass., discuss this important subject. The lecture was most interesting and has been the topic of discussion around the campus ever since.

The speaker at the meeting on Dec. 10 in Robinson Hall was L. E. Clover, superintendent of turbine testing, General Electric Company, Lynn, Mass., whose subject was "Opportunities for Young Engineers in Industry." Mr. Clover formerly traveled extensively through the country, interviewing graduating engineers in connection with his duties as an engineering personnel man, and spoke with authority on the qualifications of a good engineer and the problems apt to confront the young graduating engineer. A lively discussion followed Mr. Clover's interesting lecture.

Villanova College Branch

The purpose of the meeting held on Nov. 14 was to appoint a committee for a new membership drive. Those appointed were: Julius Palley, chairman, and Carroll Andrews, assistant. Since most of the members are seniors and Navy V-12 trainees, a prospective civilian member, Stephen Gasparovic, was appointed to the committee, to help stimulate civilian membership among the underclassmen.

On Nov. 26 a film entitled "Molding and Machining of Thermosetting Plastics" was shown. Julius A. Palley, a student member, gave a short talk explaining the various methods of molding plastics.

George Washington University Branch

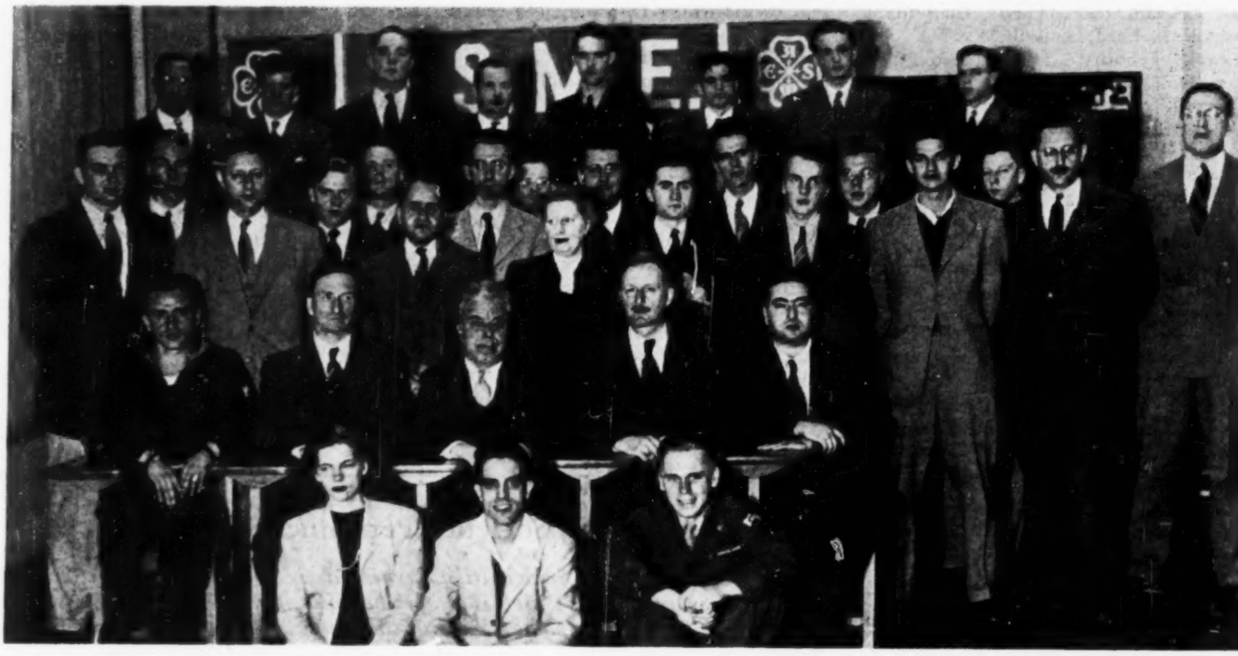
At the meeting on Nov. 7 held in the Government Building, room 203, two committees were appointed, Program and Membership. For the first, members volunteered to serve as follows: Bob Kemelhor, chairman, and Messrs. Manucia, Gaines, Mullins, Armstrong, and Reich. Those volunteering to serve on the membership committee with Mary Freeman as chairman were: Messrs. Matlow, Manville, and Varney. John C. Niedermair, Bureau of Ships, Navy Department, spoke on the development of the LST. His talk was interesting and informative, and he obligingly answered many questions.

University of Wisconsin Branch

On Nov. 27 a meeting was held in the Wisconsin Memorial Union, when the program consisted of a talk on steam turbines by C. W. Bloedorn, junior member A.S.M.E., steam-turbine department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. He first showed a movie illustrating the principles of operation of steam turbines and also showed many slides of various types of steam turbines and explained their construction. A discussion period followed the talk. In the audience was Mr. Schudt, student chairman of the Milwaukee Section of the S.A.E., and several other visitors from Madison, Wis., and other cities. These guests were introduced by Chairman Hlavka.

Worcester Polytechnic Institute

The Dec. 13 meeting held in the Higgins Laboratories was opened by H. L. Schimmack, president. Plans were discussed for a proposed joint meeting with the Worcester Section A.S.M.E. The program consisted of a film entitled "The Story of Willow Run."



GEORGE WASHINGTON STUDENT BRANCH MEMBERS AT A MIXER

Engineers to Aid Technical Libraries in Devastated Countries

An appeal is being made by the Committee on International Relations of The American Society of Mechanical Engineers for contributions of technical books and magazines and donations in money with which to restock war-devastated libraries, to modernize those that by the hostilities have been shut off from the outside world, and to advance technical progress in countries where it hitherto has not been developed.

The Committee has already received urgent requests for technical literature from China and the Philippines and for a specific list of books from Czechoslovakia.

In order that these requests may be filled and the other objectives of the Committee may be attained, engineers who have technical books and periodicals to contribute to foreign libraries are urged to send at once to the A.S.M.E., attention of George A. Stetson, editor, a list of available material, in which is stated title, author, publisher, and date of publication of each volume.

The books themselves should not be sent until shipping instructions are received from the Committee, as distribution points may vary with the location of the contributors and of the libraries to which they are to be sent.

Money Also Needed

Money is needed for the purchase of new books for libraries without financial resources. Contributions may be made in the form of checks drawn to the order of the A.S.M.E. and marked for the International Book Fund.

The Committee hopes to provide means by which each book will be marked with the name of the engineer who contributes it. By thus personalizing each book it is hoped to promote international good will within the engineering profession.

Personnel of the Committee

The A.S.M.E. Committee on International Relations is headed by R. M. Gates, president, Air Preheater Corporation, New York, N. Y. Other members are Ernest Pragst, of the International General Electric Company, Schenectady, N. Y.; Joseph Pope, vice-president, Stone and Webster Engineering Corporation, New York, N. Y.; Ralph S. Damon, vice-president, American Airlines Inc., New York, N. Y.; and Fenton B. Turck, of Turck, Hill and Company, New York, N. Y. Advisory members of the Committee are W. L. Batt, Wallace Clarke, Morris L. Cooke, Howard Coonley, Col. P. R. Faymonville, A. M. Greene, Jr., Henry A. Lardner, John C. Parker, Edmund A. Pratt, H. S. Rogers, and Major General Charles M. Wesson. C. H. Kuechler is secretary of the Committee. The solicitation of books for foreign libraries is under the direction of Mr. Pope.

New Course Offered by University of Michigan

A NEW four-year curriculum in Mechanical and Industrial Engineering will be offered by the College of Engineering at the University of Michigan, effective with the start of the spring term on March 4.

The new curriculum, which replaces a five-year program, will lead to a degree of bachelor of science in engineering (industrial-mechanical). The five-year program was based on the requirement of 140 hours of undergraduate work for the degree of bachelor of science in engineering (mechanical engineering) and 24 hours of graduate work for the degree of master of science in industrial engineering.

No change has been made in the basic requirements for the new four-year curriculum and 140 hours of undergraduate work will be required for the degree. It is felt that a student who wished to take further work in the industrial field will find no difficulty in selecting courses to suit his requirements.

A.S.M.E. Local Sections

Coming Meetings

Akron-Canton. February 4. Akron, Y.W.C.A. at 6:30 p.m. Subject: "Modern Miracles in Glass," by C. J. Phillips, manager, electronic sales department, Corning Glass Works, Corning, N. Y.

Anthracite-Lehigh Valley. February 22. Dinner at 6:30 p.m. Meeting at 8:00 p.m., Packard Laboratory, Lehigh University, Bethlehem, Pa. Subject: "Industrial Gaging and Precision Measurement," by Colonel Carmody with Colonel Hambleton assisting in demonstration, Army Ordnance Department.

Baltimore. February 25. This meeting will be in charge of H. W. Hyde.

Boston. February 14. Northeastern University, Boston, Mass., at 8:00 p.m. Subject: "Jobs for the Gyro," by Charles S. Draper, professor of aeronautical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Central Illinois. February 14. University Club, Peoria, Ill., at 8:00 p.m. Subject: "Elimination of Smoke From Locomotives by Use of Overfire Air Jets," by E. V. Benton and

R. B. Engdahl, fuel engineers, Louisville & Nashville Railroad, Louisville, Ky.

Chicago. February 5. Little Theater, Civic Opera Building, Chicago, Ill., at 7:15 p.m. Subject: "The Chicago Airport Problem," by E. P. Lott, director of design, buildings, and airports, United Air Lines. Chairman of the Chicago Airlines Technical Committee.

February 19. Little Theater, Civic Opera Building, Chicago, Ill., at 7:30 p.m. Subject: "Heat Transfer in Gun Barrels," by George A. Hawkins, professor of thermodynamics, Westinghouse research professor of heat transfer, Purdue University, Lafayette, Ind.

Colorado. February 8. Oxford Hotel, Denver, Colo.; dinner at 6:30 p.m.; meeting at 7:30 p.m. Subject: "The Gas Turbine's Plan in Electrical Power Generation, Transportation and Aviation," by John R. Carlson, central-station steam engineer, Westinghouse Electric Corporation, So. Philadelphia Works, Philadelphia, Pa.

Detroit. February 5. Rackham Bldg. at 8:00 p.m. Subject: "The Gas Turbine In Aviation," by S. R. Puffer and J. S. Alford, General Electric Company, Schenectady, N. Y.

Philadelphia. February 26. Philadelphia Engineers' Club, 1317 Spruce St., Philadelphia, Pa. Subject: "New Uses for Oxygen to Revolutionize Industry," by J. H. Rushton, University of Virginia, University, Va.

Plainfield. February 20. Masonic Hall, Westfield, N. J., at 8:15 p.m. Subject: "Powder Metallurgy," by Malcolm F. Judkins, Firth-Sterling Steel Company, McKeesport, Pa.

Providence. February 5. Providence Engineering Building, 195 Angell St., Providence, R. I., at 8:00 p.m. This meeting will be in the form of a symposium on variable-speed drives and controls. Subjects: "Mechanical Designs and Operating Principles," by John A. Hrones, associate professor mechanical engineering, Massachusetts Institute of Technology, Cambridge, Mass.; "Fundamentals and Advantages of Fluid Mechanics as Used in Hydraulic Transmissions," by George F. Maglott, hydraulic engineer, Brown & Sharpe Mfg. Co., Providence, R. I.; "Electric Designs for Variable Speeds and Controls," by R. Moore, industrial-engineering division, General Electric Company, Schenectady, N. Y.

Washington, D. C. February 22. The PEPCO Auditorium, 10th and E. Sts., N. W., Washington, D. C., at 8:00 p.m. Subject: "Transportation-Locomotives of the Future." This will be an opportunity for you to hear four outstanding speakers in this field who will bring you four types of locomotives, giving you the privilege of discussing each one as follows: "Gas Turbines," by J. T. Rettaliata, Allis-Chalmers Manufacturing Company; "Diesel Locomotives," by R. Tom Sawyer, American Locomotive Company; "Steam Locomotives," by Charles E. Heilig, Baldwin Locomotive Works; and "Electric Locomotives," by W. A. Brecht, Westinghouse Electric Corporation.

Metropolitan Section

Feb. 4, 7:30 p.m., Room 501.[1] Materials Handling Division. "Palletized Shipments and World-Wide Distribution." "Pallet Shipment by Motor Truck." "Problems and Opportunities in Pallet Shipment by Railroad." "Modernizing Handling of Cargo by Steamship."

Feb. 5, 7:45 p.m., Room 502.[1] Fuels Division. "The Coal-Burning Gas Turbine."

Feb. 7, 7:30 p.m., Room 1105.[1] Engineers' Forum. "Commercial Aspects of the Engineer's Problem."

Feb. 7, 7:30 p.m., Room 502.[1] Rubber & Plastics Division. "A New Impact Evaluation and Its Application to the Design of Molded Plastics Parts."

Feb. 13, 7:30 p.m., Room 502.[1] Management Division. "Essentials of a Sound Pension Plan."

Feb. 14, 2 p.m., Room 1101.[1] Woman's Auxiliary. "Figure Control and Fashion."

Feb. 15, 7 p.m., Room 1101.[1] Photographic Division. "Postwar Photography."

Feb. 19, 6:30 p.m. and 7:30 p.m. Childs Restaurant, 109 West 42nd St. Junior Group Dinner at 6:30 p.m. Meeting at 7:30 p.m. "Opportunities in Sales Engineering."

Feb. 21, 7 p.m., Room 502.[1] Marine Power Division. "Air-Ejection Apparatus for Marine Power Plants."

Feb. 26, 8 p.m., Room 503.[1] Industrial Instruments and Regulators. "Automatic Control Systems' Transient Response."

Feb. 28, 7:30 p.m., Room 502.[1] Oil and Gas Power Division. "Trends in the Diesel Fuel Supply Picture."

Feb. 28, 7:30 p.m., Room 1105.[1] Engineers' Forum. "Hobbies."

[1] Engineering Societies Building, 29 West 39th St., New York, N. Y.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	212 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

PRODUCTION ENGINEER, Canadian, 37. Experience: Design, installation, management, production planning, and control systems; processing; material control; tooling; product design. Industries: Automobile; radio, aircraft; heavy metal. Northeast or Canada. Will travel. Me-996.

MECHANICAL ENGINEER, 27, married, graduated 1941, course in naval architecture. Naval officer, $4^1/_2$ years' experience in ship-repair work. Positions held: ship superintendent, machine superintendent, repair officer, executive officer, and commanding officer. Desires mechanical-engineering position leading to engineering management with manufacturing concern. Me-997.

MECHANICAL ENGINEER, 34, experienced in steam power plant and refrigeration design, installation and maintenance, ship and engine repair; some medium machine design. Interested in connection with chemical or process plant. Me-998.

[1] All men listed hold some form of A.S.M.E. membership.

INDUSTRIAL ENGINEER, 32, graduate, desires position methods or production department, established manufacturer. Three years' machine-shop methods and plant-layout experience. Four years' ammunition supply officer, last as major. Me-999.

INDUSTRIAL ENGINEER, thoroughly experienced in installation and administration of wage incentives, job evaluation, cost systems. Methods improvements alone have more than justified salary. IE graduate, young, New York, N. Y. Excellent writer. Me-1.

MASTER MECHANIC, 33, married. Fifteen years' experience, familiar with all shopwork, construction and maintenance programs, and engineering departments. Foreign or domestic; speaks Spanish. Me-2.

MECHANICAL ENGINEER, 42. Research, development, sales promotion, and technical instruction. Internal-combustion power plants and heat transfer. Position offered and integrity of firm more important than location. Me-3.

MECHANICAL ENGINEERING GRADUATE, 25. Two years' supersonic aerodynamic research, one year's machine-shop experience. Aptitude

for theoretical analysis. Desires position as research technician along mechanical, physical, or chemical lines. Me-4.

GRADUATE MECHANICAL ENGINEER, top fifth of class, age 26, married. Toolmaker apprentice graduate. One and one-half years' tool-design experience. Desires position as project, development, or design engineer. Location immaterial. Me-5.

STRUCTURAL RESEARCH ENGINEER, 28, licensed. Six years' experience design and applied mechanics; structurally approved whole of aeronautical research laboratory's design; designed reinforced-concrete, steel, timber flood-control structures; seeks employment, Metropolitan area. Me-6.

DIRECTOR OF ENGINEERING, 45. Twenty years' broad experience chemical, oil refining, process equipment, and engineering-company activities. Proved ability to organize and administer engineering department. Successful experience in supervising development of new processes, design and construction of plants and facilities and all types of process-industry equipment. Employed and reputation well-known in chemical and engineering fields. Me-7.

DEVELOPMENT ENGINEER, graduate mechanical engineer with creative mind, desires position development engineer manufacturer medium-sized machinery or junior executive capacity. Eight years' industrial experience; latter two Naval Reserve Officer Ordnance repair. Excellent composite knowledge machinery, including design, manufacturing, application. Know machine-shop practice and practical ferrous metallurgy. Experienced design special machinery, including hydraulics. Prefer New York, N. Y.; will consider others. 32, married, now available. Me-8.

POSITIONS AVAILABLE

CHIEF DRAFTSMAN with at least 10 years' experience in plant layout and preferably with some rayon-plant experience. Must be able to supervise 20–30 draftsmen in steam, concrete, piping, and process plant equipment. $6000–$7500 year. New York, N. Y. W-6369.

GENERAL MANAGER. Will be operating head of bronze foundry and machine shop. Work includes direction of shop as well as sales. $12,000–$15,000 year. Pennsylvania. W-6403.

MECHANICAL ENGINEER with 5 to 10 years' industrial power-plant design and layout experience, to prepare plans and specifications for equipment and installation from power survey data. $5200 year. New York, N. Y. W-6410.

FOOD TECHNOLOGIST, 28–35, to supervise development of raw materials and finished products as well as plant-control work. Products consist of soda fountain and bakery supplies; jams, jellies, flavors, dry mixes, and emulsions for bakery use. Must have experience in commercial food field. Salary open. New York State. W-6414-D-2624.

INDUSTRIAL ENGINEER, 25–35 preferred, with some experience in installation, methods, and planning for office systems. $6000–$7500 year. New York, N. Y. W-6419.

PLANT ENGINEER to act as assistant to chief plant engineer on equipment setup and layout, preferably with this experience in either food or chemical industries. Some building-design experience desirable. $4800 year. Maryland. W-6422.

DESIGNERS. (a) Designers, experts, of industrial power plants, to determine load requirements of the plant, select preferred commercial equipment available and detail piping up of the apparatus. (b) Designers experienced in air conditioning for complete air conditioning in commercial, industrial, and process buildings. Must be well qualified in these lines with proved record of performance of work done. Salaries open. New York, N. Y. W-6423.

ASSISTANT GENERAL MANAGER, 30–45, with heavy sheet-metal fabrication experience, for manufacturer of power and heating boilers. $5000 year. Eastern Pennsylvania. W-6424.

MANAGER OF OPERATIONS, 40–50, graduate engineer, with experience in power plants, transmission and distribution, operation and development. Experience in steam-plant construction and operation essential. Must have administrative ability, initiative, and enthusiasm for public-utility work. Excellent opportunity in rapidly growing public-utility company. $15,000 up year. Philadelphia, Pa. W-6426.

VOCATIONAL TRAINER, 35–55, with minimum of 6 years' experience, especially training supervisory employees, course planning; to prepare instruction material for training of various engineering and maintenance occupations. Traveling involved. $4000 year. Pennsylvania. W-6436.

MECHANICAL ENGINEER, under 45, with 10 to 15 years' plant engineering experience in food-processing industries, to supervise process layout, draw up specifications, and coordinate engineering and purchasing of equipment. $5200 year. New York, N. Y. W-6440.

MECHANICAL ENGINEERS, 2, 30–35. (a) One with experience in machine design, factory layout, and general plant engineering in a food-processing plant. (b) One with some experience in plantation and agricultural equipment, particularly in devising labor-saving machinery. $6000–$8500 year. Company pays transportation for applicant and family. Hawaii. Interviews, New York, N. Y. W-6444.

SHOP AND MAINTENANCE SUPERINTENDENT, 35–45, technical graduate or equivalent, five or more years' experience in organization and management of a manufacturing department, including supervision of personnel, cost reduction, modern methods, planning and scheduling. Will be responsible for office, shop, and field service forces, about 75 people. About $5000 a year. Northern New Jersey. W-6452.

ENGINEERS. (a) Superintendent construction of a steam power plant, graduate engineer or having broad experience installation of high-pressure steam boilers, piping and turbines, together with all appurtenances. To $5200. (b) Mechanical engineer, graduate, experienced steam-power-plant construction and capable taking charge of the engineering features involved in the construction of a steam power plant. To $5460. Virginia. W-6457.

DIESEL PLANT ENGINEER, preferably with extensive Diesel maintenance and installation experience for operation and maintenance of utility power plant. Will consider technical graduate with maintenance and operating experience. Prefer man with stationary plant experience. Spanish desirable. Apply by letter giving details of education, training, experience, and salary earned in each position. Ecuador. W-6477.

PLANT SUPERINTENDENT, mechanical graduate, to take charge of a job shop specializing in the manufacture of pipes, valves, and fittings, and employing 125–150 people. Must be good administrator and have had union-labor-relation experience. $7200. New York, N. Y. W-6481.

CHIEF ENGINEER, mechanical graduate, 35–45, who has had some experience in maintenance and construction for a process plant employing about 600 people. Should have had some experience in boiler-plant pumps, piping, conveyers, etc. $6000–$7000. New York Metropolitan area. W-6490.

INDUSTRIAL ENGINEER particularly experienced in time study, bonus, and incentive plans. Will head this work for twelve plants of the company. Must have good personality and ability to sell plan to plant managers. Some traveling. $6000 year. New York, N. Y. W-6498.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after February 25, 1946, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ANDREWS, L. V., Worcester, Mass.
BAEHR, ERNEST, JR., Forest Hills, N. Y.
BARDONNER, WILMER J., Fort Wayne, Ind.
BARRETT, M. J. (LIEUT.), Beckenham, Kent, England
BEAVER, ROY C., Greenville, Pa.
BLISS, JOHN C., Istanbul, Turkey
BLOOM, FRED S., Pittsburgh, Pa.
BLUE, CLARENCE H., Tulsa, Okla.
BOLLIER, J. C., Peoria, Ill.

BORGESON, SIDNEY E., Westfield, N. J.
BOSSE, EARL W. (LIEUT.), San Francisco, Calif.
BOZOVICH, HENRY G., Palo Alto, Calif.
BRADFIELD, GEORGE K., JR., Hackensack, N. J.
BRYANT, CHARLES B., Washington, D. C.
BURDICK, JOHN S., JR., Stratford, Conn.
BUTTERILL, H. J., Richmond Hill, Ontario, Canada
CHANDLER, HERBERT E., Chicago, Ill.
CLINGER, JOSEPH SAMUEL, JR., Burgoon, Ohio
COBLEIGH, HENRY R., White Plains, N. Y. (Rt & T)
CONNELLY, W. J., Harrison, N. Y.
CORRIGAN, W. E., Tenafly, N. J. (Rt & T)
COUCH, R. B., Bremerton, Wash.
COX, PERCY N., Baltimore, Md.
CRISSMAN, H. U., Freeport, Texas
CRUMLEY, MEARL T., Jacksonville, Fla.
DAVEY, JOHN S., Riverside, Conn.
DEBRUIN, N. M., Houston, Texas
ECKEL, CLARENCE L., Boulder, Colo.
EGNER, PAUL O., Houston, Texas
FADDIS, LEWIS P., Fort Wayne, Ind.
FARRELL, BARTHOLOMEW J. (LIEUT.), Chicago, Ill.
FAWCETT, FRANK A., Narberth, Pa.
FOX, ELTON B., Oakland, Calif.
FRIEDRICH, W. G., Washington, D. C. (Re)
GENGER, V. K., St. Joseph, Mich.
GINSBERG, NORMAN I. (T/5), New Rochelle, N. Y.
GLUNT, DAVID (LIEUT. COMDR.), New York, N. Y.
GODSHALL, S. ELMER, Broomall, Pa.
GREEN, ARTHUR F., Navy Yard, S. C.
GULRAJANI, B. K., Milwaukee, Wis.
HANSON, ARNOLD J., New York, N. Y.
HEIBERG, ARTHUR B., Cuyahoga Falls, Ohio
HEIKOFF, EUGENE (LIEUT.), New York, N. Y. (Re)
HOLLOWAY, SCOTT, Lafayette, Ind.
HOLT, SHERWOOD G. (LIEUT.), Washington, D. C.
HOPE, RALPH E., Portsmouth, Ohio
HOYER, CARL O., Springfield, Mass. (Rt)
JACOBS, RAYMOND H., Boston, Mass.
JENKINS, R. H., Washington, D. C.
JENSEN, ALLEN H., New Orleans, La.
KANN, H. E. ARTHUR, West Haven, Conn.
KARTORIE, VALENTINE T., York, Pa.
KENNICOTT, WILBUR LORENZO, Latrobe, Pa.
KINCAID, JOHN H., Cleveland Heights, Ohio
KITTREDGE, CLIFFORD P., Princeton, N. J.
KNIGHT, W. F., Akron, Ohio
LAIR, P. H., Waban, Mass.
LANKFORD, W. T., Pittsburgh, Pa.
LEHMANN, JOHN R., Rochester, N. Y.
LEVY, SAMUEL, Washington, D. C.
LEWIS, KENNETH D., Oakland, Calif.
LLOYD, TOM C., Springfield, Ohio
MACKLEY, J., London, England
MANKUTA, HARRY, Cleveland, Ohio
MASON, FRED E. (MAJOR), Miami, Fla.
MCCARTHY, JOHN J. (LIEUT. COMDR.) Amityville, N. Y.
MCCOY, ROGER D., Joliet, Ill.
MCINTYRE, DONALD F., Philadelphia, Pa.
MCPHERSON, DONALD F., Penfield, N. Y.
MCRAE, H. C., Cleveland, Ohio
MEIKLE, W. R., Larchmont, N. Y.
MERRITT, RICHARD T., Charleston, W. Va.
MEYER, CARLETON W., New York, N. Y.
MOFFAT, ELMER G., York, Pa. (Rt & T)
MOODY, LUCIAN B. (COL.), Washington, D. C.
MOUNT, WILBUR S., Suffern, N. Y.
MUNTER, ERNEST L., Rensselaer, Ind.
NAYLOR, N. C., Chicago, Ill.
PALMER-PERSEN, DAVID, Newtonville, Mass.
PAQUETTE, A. L., Swissvale, Pa.
PATCHEL, HERBERT O., JR., Laurel Springs, N. J.
PEARSON, ROBERT M., Springfield, Ohio
PENFOLD, NORMAN C., Chicago, Ill.
PODBIELNIAK, WALTER J., Chicago, Ill.
PYE, DAVID W., Sea Bright, N. J.
QUIRK, ROBERT W., Chicago, Ill.
RATZEL, ELMER A., Chicago, Ill.
REEVES, HARVEY E., Flushing, N. Y.
RHYS, CYRIL O., Westfield, N. J. (Rt)
RICHARDSON, HENRY A., New York, N. Y. (Rt)
ROGERS, RALPH H., Jackson, Miss.
ROLLINS, D. C., South Charleston, W. Va.
ROSE, HERBERT ARTHUR, Seattle, Wash.
RUSHTON, J. HENRY, Charlottesville, Va.
SAMPIETRO, A. C., Coventry, England
SCHUYLER, JOHN D. (ENSIGN), Berkeley, Calif.
SCHWARTZ, EDWARD W., Pompton Plains, N. J. (Re)
SEYFANG, WILLIAM G., Buffalo, N. Y.
SHARP, RALPH T., Fort Wayne, Ind. (Re)
SHOEMAKER, ROBERT J., Chicago, Ill.
SIZELOVE, OLIVER J., Newark, N. J.
STANSFIELD, C. T., New York, N. Y. (Rt)
STASKUS, CHARLES S., Angola, Ind.
STEVENS, ROSCOE C., JR., Kansas City, Kansas
TARBELL, VIRGIL, Erie, Pa.
TAYLOR, J. E., Jackson Heights, N. Y.
TERRY, SPENCER B., Warren, Ohio
THIEL, DONALD G., Stockton, Calif.
THIEL, FRED R., Stockton, Calif.
THOMPSON, J. SCOTT, Tulsa, Okla.
TROY, SEYMOUR, Mount Vernon, N. Y.
ULMER, RICHARD C., New York, N. Y.
VAN PATTER, H. S., Westmount, Quebec, Canada
VAN WAGENEN, EDWARD, Green Cove Springs, Fla.
WANGAARD, FREDERICK F., Hamden, Conn.
WEHLAGE, EDW. F., Rochester, N. Y.
WELSH, JOHN N., Allison Park, Pa.
WEST, JOHN F., JR., Allentown, Pa.
WHYTE, CARL B., Lake Charles, La.
WILCOCK, DONALD F., Lynn, Mass.
WILLSEA, RAYMOND, Ardsley, N. Y. (Rt)
WINTERS, RAY, Kansas City, Mo.
WOLF, JOSEPH, Philadelphia, Pa.
WUNDERLICH, RALPH T., Cleveland Heights, Ohio
YORGIADIS, ALEXANDER JOHN, Greenwich, Conn.

CHANGE OF GRADING

Transfer to Fellow

CRAIG, OLLISON, Worcester, Mass.
DEPPELER, J. H., Weehawken, N. J.

Transfer to Member

ARRIGO, VINCENT P., Columbus, Ohio
CREDE, CHARLES E., Cambridge, Mass.
DAUBER, CLARENCE A., Cleveland Heights, Ohio
GLICK, A. E., St. Louis, Mo.
GOODEN, MAURICE P. (MAJOR), York, Pa.
HELLA, ROBERT, Combined Locks, Wis.
JACKSON, JOHN W., College Park, Md.
JOHNSON, BOYD M., Perth Amboy, N. J.
JUER, ROBERT (CAPT.), Dumas, Texas
LOVE, CLYDE P., Potrerillos, Chile
MCCABE, C. H., Wakefield, Mass.
MESSER, ROWLAND E., Bremerton, Wash.
MILLER, H. C. L., JR., Richmond, Va.
NEWSTROM, CARL L., Harper, Wash.
RIPPE, CARLOS C., Barranquilla, Colombia
SCHWARZ, FREDERICK W., Lansdowne, Pa.
SEXTON, SAMUEL B., 3d, Dayton, Ohio
STANEK, JEROME H., Milwaukee, Wis.
UICKER, GEORGE B., Woodbury, N. J.
WEBBER, LAURANCE E., Berwick, Maine
WHEELER, GARDNER E., JR., West Barrington, R. I.

Transfers from Student Member to Junior 20

Necrology

THE deaths of the following members have recently been reported to headquarters:

ADAMS, PORTER H., December 5, 1945
EMERY, ALBERT H., December 12, 1945
FLOWERS, ALAN E., December 3, 1945
GRAVES, GEORGE R., October 15, 1945
JUDD, HORACE, December 1, 1945
MARBURG, A. WILLIAM, February 18, 1944*
MARKARDT, JOHN E., December 25, 1945
WHEELER, CLIFTON H., JR., November 24, 1945
WOOLSON, WILLIAM D., December 10, 1945

* Died in line of duty.

A.S.M.E. Transactions for January, 1946

THE January, 1946, issue of the Transactions of the A.S.M.E. contains:

Rate of Temperature Change in Short-Length Round Timbers, by J. D. MacLean

Flame-Temperature Measurements in Internal-Combustion Engines, by O. A. Uyehara, P. S. Myers, K. M. Watson, and L. A. Wilson

Polar Diagram for Tuning of Exhaust Pipes, by Troels Warming

Substitution of Lower-Quality Industrial Diamonds in Diamond Dresser Tools, by H. Whittaker

Measurements of Temperatures in Metal Cutting, by A. O. Schmidt, O. W. Boston, and W. W. Gilbert

Charts for Fuselage Torsion Versus Control-Service Flutter, by W. T. Thomson

Thermal Accommodation Coefficients, by M. L. Wiedmann and P. R. Trumpler

Certain Aspects of High-Pressure Centrifugal Pumping Cycles, by I. J. Karassik

The Behavior of a Hot-Wire Anemometer Subjected to a Periodic Velocity, by R. C. Martinelli and R. D. Randall